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ABSTRACT

The State Planning System (SPS) is a policy-oriented management tool intended to help analyze the interrelated effects of alternative policies and their relationships to state goals. Two pilot-test case studies are described--the SPS tuition policy evaluation conducted in Colorado, and New York's SPS evaluation of the applicability of large scale quantitative models to general postsecondary education policy-making situations. Each case study also contains supporting appendices providing the mathematical equations and other details related to the SPS design employed by each state. (Author/CMV)

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STATE PLANNING SYSTEM CASE STUDIES

Technical Report 91

Edited by
Ellen Cherin

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PREFACE

The State Planning System (SPS) is designed to assist state-level postsecondary education planners in the analysis of issues and problems. The user selects and describes the issue to be addressed, designs the analytical framework that will yield the desired results, selects the variables, assigns values to each, and provides the data. The SPS software and associated documentation help organize the data to support the design. The software then analyzes the data through its simulation and optimization capabilities and provides a flexible set of reporting formats in which to display the results.

The SPS is not a specific model or analytical construct. Rather, it becomes a "model" once the user selects the design that will best address the problem or opportunity to be analyzed. Thus the SPS, which can be used in day-to-day data analysis or to model complex state-level problems, places no a priori requirements on the particular data or design that must be used and can become as many models as the user needs to address a series of issues.

The SPS is designed to be implemented on a wide variety of computer systems with little or no modification. It can operate in interactive or batch mode, is written in ANSI FORTRAN, and has been installed on IBM, Control Data, Honeywell, and UNIVAC computer systems. A fairly large capacity computer system is required since the programs may take as much as 30,000 words of storage.

Installation of the SPS software does not automatically provide the user with the background necessary to fit the SPS to a specific problem. As in any modeling effort, available data and the nature of the selected design relationships may limit the applicability or accuracy of the results. Some staff capability in operations research or computer sciences is useful. Also, users can obtain assistance from NCHEMS staff to initially install the SPS and to help develop the designs necessary to address specific state problems.

The SPS was developed by Dr. Vaughn Huckfeldt (formerly with NCHEMS and now director of the National Policy Analysis Center, Boulder, Colorado) and by Mark Chisholm, Ellen Cherin, and Roger Bassett of NCHEMS. The development process for the SPS began in late 1972 with the National Planning Model project, which was under a contract with the U.S. Office of Education. That initial work resulted in a prototype operational model for use in analyzing the effects of alternative financing plans on access to higher education.

In 1974, development of the State Postsecondary Education Planning Model (SPEPM) was funded under a contract with the National Institute of Education. The developmental work was completed in early 1975 and the software was pilot tested in Colorado, Maryland, and New York in late 1975 and early 1976. The SPS was successfully implemented and used in each of these states and has since been implemented in Oklahoma, Virginia, Minnesota, and South Dakota. In late 1976, the project name was changed to the State Planning System to avoid the confusion caused by the word "model" in the project name.

Major developmental contributions were made by three people outside NCHEMS. Dr. George Weathersby of Harvard University (recently director of the Office of Research for the presidentially appointed National Commission on the Financing of Postsecondary Education) contributed to the planning philosophy of the National Planning Model. Dr. Salvatore Corallo of the U.S. Office of Education added to NCHEMS's knowledge of planning model concepts. And Dr. Leon S. Lasdon of Case Western Reserve University contributed to the development of the nonlinear dynamic optimization algorithm and to the review of the SPS software.

The production schedule for this and other documents related to the SPS was reviewed with the Fiscal Affairs and Operations Committee of the NCHEMS Board of Directors at its October 1976

meeting, and the software and supporting documents have been approved for release by the NCHEMS Board of Directors.

The Center has tested the software to determine that it operates as the documentation indicates. The Center will notify users of any potential problems in the software and will make any necessary changes after initial release. No warranty, expressed or implied, is provided with the software.

The *Introduction to SPS* (NCHEMS Technical Report 86), The *Modeling and SPS* (NCHEMS Technical Report 89), and The *SPS Case Studies* (NCHEMS Technical Report 91) will go to the holders of 1976 subscriptions to NCHEMS publications. All 12 SPS documents (the documents are described and diagrammed inside the cover) and the SPS distribution tape, containing the software and several test designs, can be purchased at cost, either individually or as a set, by any interested party. In addition, implementation assistance for the SPS can be purchased from NCHEMS. This assistance, which based on the pilot-test experience, is strongly advised, can consist of NCHEMS staff days and travel to assist in:

1. Installing the software
2. Conducting a training seminar
3. Conducting a design seminar
4. Assembling data
5. Entering the initial design and data
6. Validating and modifying the intitial design
7. Analyzing the results

The following are NCHEMS documents that are superceded by the SPS documents listed inside the front cover:

Cherin, Ellen; Chisholm, Mark; Huckfeldt, Vaughn; and Smith, Mark. *State Postsecondary Education Planning Model Software System.* Boulder, Colo.: National Center for Higher Education Management Systems [NCHEMS] at Western Interstate Commission for Higher Education [WICHE], 1975.

Chisholm, Mark. *State Postsecondary Education Planning Model Software Documentation.* NCHEMS Technical Report 80. Boulder, Colo.: NCHEMS at WICHE, 1976.

Huckfeldt, Vaughn. *A Preliminary Framework for the State Postsecondary Education Planning Model.* Boulder, Colo.: NCHEMS at WICHE, 1974.

_____. *An Introduction to the State Postsecondary Education Planning Model.* NCHEMS Technical Report 77. Boulder, Colo.: NCHEMS at WICHE, 1976.

_____. *A Design Guide for the State Postsecondary Education Planning Model.* NCHEMS Technical Report 78. Boulder, Colo.: NCHEMS at WICHE, 1976.

_____. *State Postsecondary Education Planning Model Training Manual.* NCHEMS Technical Report 79. Boulder, Colo.: NCHEMS at WICHE, 1976.

Huckfeldt, Vaughn; Cherin, Ellen; and Chisholm, Mark. *State Planning System Case Studies.* NCHEMS Technical Report 81. Boulder, Colo.: NCHEMS at WICHE, 1976.

Huckfeldt, Vaughn; Cherin, Ellen; and Chisholm, Mark. *State Planning System Data Procedures.* NCHEMS Technical Report 82. Boulder, Colo.: NCHEMS at WICHE, 1976.

ACKNOWLEDGEMENTS

The State Planning System (SPS) is the result of the combined efforts of many individuals. In particular, the representatives from the SPS pilot-test states were most helpful in their use of earlier test versions of the software, and in providing their guidance, review comments, and suggestions concerning documentation. Since each pilot-test state user was required to develop a specific set of design relationships for a particular problem, the extent of their efforts went beyond the normal pilot-test commitment and deserves special acknowledgement. Those involved from each of the states were:

Colorado Commission for Higher Education:
- Dr. Frank Abbott, Executive Director
- Dr. William Adrian
- Mr. Edward Lyell
- Mr. Carleton Ekberg

Maryland State Board for Higher Education:
- Dr. Sheldon H. Knorr, Commissioner of Higher Education
- Mr. John E. Clayton
- Dr. Stephen R. Hample
- Mr. B. Kerry Gustafson

New York Department of Education:
- Dr. William Fuller, Associate Commissioner
- Dr. Paul Wing
- Mr. Michael Cruskie
- Dr. Shimon Awerbuch
- Mr. Steve Cohen
- Ms. Jackie Skolnik
- Ms. Judy Hutchison

Significant ideas for the construction of the SPS were provided by Kent Weldon and Mark Smith of NCHEMS. Kent Weldon worked on the development of the National Planning Model and made many valuable suggestions regarding the SPS, and Mark Smith worked on the development of an early pilot-test version. Dr. Melvin D. Orwig has been the NCHEMS Associate Director responsible for the SPS since June 1975, and his guidance and patience are most appreciated. Other staff at NCHEMS who have contributed to the development of the SPS are Dr. Allan Service, Dr. Kent Caruthers, Dr. Robert Gray, Marilyn McCoy, and David Makowski.

The production of the SPS documents has been a lengthy and difficult task, and special thanks are extended to Cynthia Labuda for her work in preparing the tables, figures, and charts, coordinating the lengthy process of draft production, as well as typing the documents. Additional acknowledgements are given to: William Johnston, Jean Strueber, and Maureen Byers for editorial assistance, Clara Roberts for assisting in the overall coordination of the document production, Elizabeth Peto for typesetting several of the documents, and Paula Dressler for typing several early drafts of the SPS documents. Many other people, too numerous to mention, were involved in the project at one time or another, and their help has also been appreciated. It should be emphasized, however, that any mistakes or errors in the documents are the sole responsibility of the authors.

Chapter I

Introduction

The State Planning System (SPS) is a flexible, policy-oriented management tool, intended to help analyze the interrelated effects of alternative policies and their relationships to state goals. It has been developed to assist state-level postsecondary education planners with a variety of tasks—from day-to-day analysis to the complex "modeling" of postsecondary education behavior in such areas as resource allocation, student enrollment patterns, enrollment and revenue impacts of alternative tuition policies, facility requirements, and faculty requirements. It has been developed in such a way that each user specifies those design relationships that are most appropriate to a state goal-achievement analysis in a particular state. It can, therefore, become as many "models" as the user needs to address a series of issues.

Because the design relationships are specified by the user, each application is unique. This case studies document is intended to describe previous designs for the information of future users. As such, it should help with the development of new designs. This document does not contain an explanation of the SPS itself. The reader is referred to the *Introduction to the State Planning System* for an overview of the SPS. A more technical discussion of the SPS components is contained in the *State Planning System Operation Guide*. Review of these two other documents will help the reader understand the individual case studies, but is not considered a prerequisite.

This document describes the Colorado and New York pilot-test case studies. Other case studies will be similarly documented as additional applications occur. Chapter II outlines the tuition policy evaluation that was conducted in Colorado, and New York's examination of the applicability of large-scale quantitative models to postsecondary education policy-making situations is contained in Chapter III. Each chapter contains the material as reported by the states with editing to provide a consistent format.

Since one purpose of this document is to provide to SPS users a source of design ideas that should allow some new SPS applications to be served by adaptations of previous designs, each of the case studies is presented in basically the same format to facilitate reference to a particular section. Each one also contains supporting appendices that provide the mathematical equations and other details related to the SPS design employed by each state.

The intent of this format is to enable each user to quickly identify those sections that are the most important and pertinent for a particular purpose without having to search through the entire text. Subsequent case studies that are documented will also follow the same format.

Chapter II

Colorado Pilot Test Design

INTRODUCTION

The pilot-test case study of the SPS in Colorado was conducted by the Colorado Commission on Higher Education (CCHE). The Commission is the statutory agency for planning and coordination of higher education in Colorado and one of its responsibilities is to collect and analyze higher education statistics.

When the Colorado state legislature wished to establish a standard tuition policy for public institutions in Colorado, the CCHE staff was asked to evaluate the current tuition policy and each of several alternatives suggested by both the CCHE staff and the Joint Budget Committee (JBC) staff of the state legislature.

PROBLEM IDENTIFICATION

Colorado tuition is set by law to be 25% of the cost of instruction for resident students (22.5% for community college residents), and 100% of the cost of instruction for non-resident students (with some institutional exceptions). Costs of instruction, calculated each year by the Legislative Joint Budget Committee staff, include all instructional costs other than capital equipment, capital facilities, and miscellaneous items at each school which are not related to the instructional mission. There have been three kinds of pressures for a re-evaluation of state tuition policies: (1) a need to generate additional revenue to offset general fund expenditures as inflation drives up the costs of instruction, (2) a concern for maintaining and perhaps even increasing access to postsecondary education for Colorado residents, and (3) a concern for examining the equitability of tuition policies among institutions. (An elaboration of these specific concerns regarding tuition as prepared for the Colorado Commissioners of Higher Education is found in Appendix I-A. A summary of the tuition policies evaluated as prepared by the CCHE and JBC staffs is given in Appendix I-B.) The third concern is of particular interest to the Commission on Higher Education. There is a state-wide tuition policy, but each institutional governing board is allowed to determine certain aspects of the policy, (e.g., the point at which a student is classified as part-time or full-time and rates for part-time students by credit hour). There are six governing boards in the state and the lack of uniformity among institutional tuition-charging practices causes access inequities to exist in the system.

GOALS AND OBJECTIVES OF THE STUDY

In conducting the case study application in Colorado, CCHE had the following goals:

Goal 1:

To test alternative tuition policies and examine the relative impact of those alternatives upon revenue expectations, tuition costs by student categories, and institutions. The purpose of this analysis was to find a standard tuition procedure, for different student types, that could be applied across all institutions to increase tuition revenue while assuming current enrollment levels.

Specific Objectives for Goal 1

a. To examine Fall, 1975 tuition revenue generated by headcount students at credit hour loads from one to thirty.
b. To examine the impact of a standard definition of part-time students on tuition per credit hour among all institutions.
c. To examine the effects of a surcharge, or extra cost, for each student taking over a certain number of credit hours.
d. To examine the effects of a standard surcharge for credit hours taken over a specified number as well as of a standard part-time instruction charging policy among all institutions.
e. To examine the impact of a standard tuition charge per credit hour, eliminating the part-time, full-time differential.

f. To identify the cost difference between graduate and undergraduate students in the university sector and examine the impact of a tuition policy based on the difference.

Goal 2:

To examine the ease, flexibility, and extendability of the SPS as compared to other modeling techniques available to CCHE.

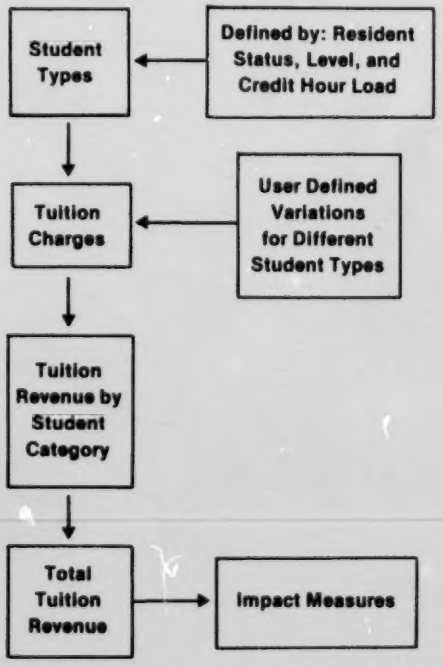
DATA SOURCES AND USE

To examine the tuition alternatives it was necessary to collect information from institutions regarding their enrollment distribution by credit hour load and tuition rates and revenue. A copy of the collection sheet is attached as Appendix I-C. This information was provided by the schools under short deadlines, creating some data interpretation problems and significant data errors during the study. These problems were corrected during the project.

Figure 1

Overview of the Colorado Design

For Each of Nineteen Institutions


Student Types
Defined by: Resident Status, Level, and Credit Hour Load
Tuition Charges
User Defined Variations for Different Student Types
Tuition Revenue by Student Category
Total Tuition Revenue
Impact Measures

After the data were collected on hand generated forms, the data were input to one computer system and then, later, transferred to the University of Colorado Academic Computing Center system where the SPS was available. (The CCHE staff did not have to install the software as the same computing facilities were used by the NCHEMS staff in developing the software.) The coding and data base specifics of the SPS were then completed by NCHEMS staff as an assistance in the pilot test activities.

DESIGN

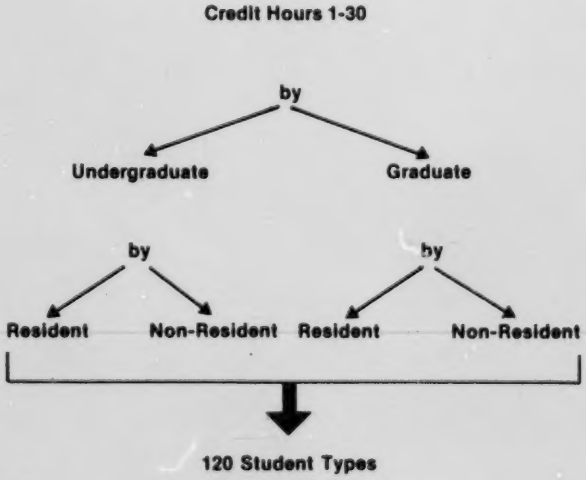
In examining tuition alternatives, the Colorado design included several components. An overview of the design may be best explained using Figure 1.

Each of the nineteen institutions was processed through the SPS separately. Basically they were each treated as an individual sector rather than aggregating them, for example, by university, four-year, and two-year institutions.

120 student types were identified for each of the nineteen institutions. Figure 2 diagrams how the 120 student types were derived using sub-classifications of: 1-30 credit hours, undergraduate/graduate and resident/non-resident. A particular student type could therefore be an undergraduate, resident

Figure 2

Student Types



student taking 13 credit hours. These student types could also be aggregated into categories or groups of students, that is, all non-resident, graduate students taking between 12 and 15 credit hours.

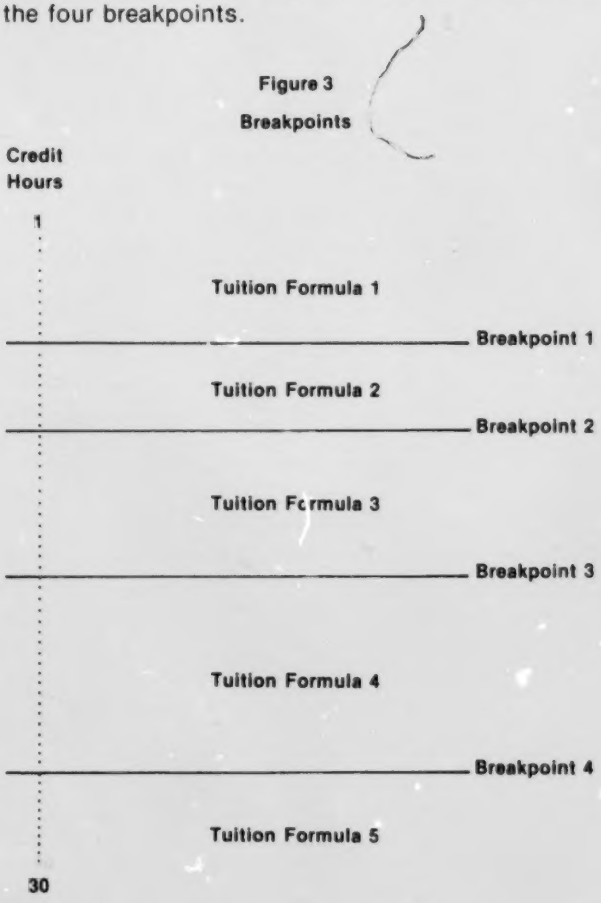
Historical tuition rates and income generated per credit hour were input as a basis for testing tuition alternatives and as a method of validation (discussed in the next section). For each of the 120 student types, a corresponding tuition charge was available. However, inflation was also used to modify last year's cost of instruction which was then used to calculate the current year's tuition rate. Since a percent of the cost of instruction was the basis for determining tuition (25% for residents, 100% for non-residents), a revised percent of last year's total cost (to reflect inflation) was used to determine the tuition charge for each of the four major student categories:

resident undergraduates
resident graduates
non-resident undergraduates
non-resident graduates

The basic formulation can be described as follows: tuition revenue by tuition category was calculated by multiplying institutional enrollment by category times the tuition charge for that category. Calculated revenue was then summed over all tuition categories to obtain a total projected tuition revenue for each institution. The design did not calculate changes in enrollment levels in response to the alternative tuition policies. For the purposes of this analysis, it was assumed that enrollment would not be affected by the slight variations in tuition being considered.

Up to this point, the calculations do not allow for any differentiation. In order to simulate or test the various tuition alternatives, breakpoints were built into the equations that were user determined according to the policy being tested. Four possible breakpoints were incorporated. That is, by grouping the student types according to the number of credit hours taken (establishing the breakpoints), tuition could be calculated differently for each of the student groups. And for each of the four breakpoints, it was possible to change various factors or variables. Among the variables that could be recognized in the equations were: breakpoints in tuition schedules (such as the break from part-time to full-time charges per credit hour); tuition policy variables (student residence, student level, and credit hour load); and tuition-charging practices (the fixed charges per headcount or credit hour, differing rates per credit hour, plateau conditions where full-time is defined as a range of credit hours, plateau conditions where full-time is defined as a range of credit hours above a minimum level, and the use of a surcharge for loads over a certain established maximum). Figure 3 illustrates the four breakpoints.

Figure 3
Breakpoints



The CCHE staff worked closely with the NCHEMS staff in developing the equations and in identifying acceptable measures of the effect on the tuition policy alternative being considered. The SPS design to test the first three tuition policy alternatives was developed within a period of two days. The mathematical formulation of the design (included in Appendix I-D) was developed by CCHE staff (who had experience in design formulation) drawing, as necessary, on the experience of the NCHEMS staff for the specifics of the SPS system.

VALIDATION/RUNS

The data base was validated by running the current tuition policy using historical functional relationships. The design formulation successfully estimated the year for which actual data existed. The validation run identified several errors in the institutional calculations of tuition revenue as reported on the data sheets. The validation run required three days of CCHE staff time, four days of NCHEMS staff time, and approximately $300 of computer time.

After additional objectives were added (Objectives c, d, and e on page 3) by senior policy makers in the state, the model was redesigned and revalidated using only one day of CCHE time, two days of NCHEMS time, and an additional $100 of computer time.

REPORTS

The results of three initial policy runs produced by the Data and Report Module (DRM) of the SPS are shown in Table 1. The tuition variations that were tested with these runs were as follows:

1. *Current policy* — Tuition is set to be 25% of the cost of instruction for resident students, 100% of the cost of instruction for non-resident students, with the full-time/part-time break determined by each institutional governing board.
2. *CCHE policy* — The basic policy was the same as the "current policy" except that full-time for tuition purposes (that is, the maximum tuition for any student) was defined as ten credit hours. Part-time tuition charges were defined as one-tenth of the full-time charge per credit hour taken, with a minimum charge equivalent to the tuition for two credit hours.
3. *The Joint Budget Committee (JBC1) policy* — The basic policy here was also the same as the "current policy" except students taking more than 15 credit hours pay a "surcharge" of 50% of the institutionally-set per credit hour rate for each credit over 15.

Other revenue and enrollment impact measures (besides total revenue generated by institutions) for the current policy and the CCHE policy for two of the 19 Colorado institutions are shown in Table 2. Based on these measures and the design developed by the CCHE, reports were produced using the DRM that indicated the percent of revenue generated by each student category (broken out by resident/non-resident and undergraduate/graduate). The DRM also provided the percentage of students enrolled by category so the analyst could readily observe shifts in relative tuition burden among student categories. These additional measures made the use of the SPS more effective in the Colorado tuition analysis.

The Colorado design was also constructed to produce "exception reports" that identified the four student types experiencing the largest percentage change in the tuition charge per headcount student (tuition charge being a measure of the student impact of the policy alternatives). Table 3 contains two of the exception reports produced by DRM. To elaborate using Table 3, non-resident graduate students taking 30 credit hours (defined as measure variable number 257 in the SPS equations) experienced the largest percentage change in the tuition charge for the JBC1 policy run at Mines University in Exception Report 260. These reports were used to identify the differential impacts of a policy on the various institutions.

The CCHE staff and JBC staff jointly prepared a list of some of the possible tuition variations that might be tested (included in Appendix I-B). Although time restrictions did not allow for the testing of all of the suggested alternatives, three of the policies proposed by the JBC staff were tested. These were run overnight and reports similar to that in Table 4 were provided (again using DRM) to further assist in the policy analysis. The proposed tuition variations were:

1. *JBC1 policy* — The same as the "current policy" except students taking more than 15 credit hours pay a "surcharge" of 50% of the institutionally-set per credit hour rate for each credit over 15.
2. *JBC2 policy* — Identical to the CCHE policy discussed earlier except prorated at 1/15 per credit (full-time was 10 credits with a minimum charge for 2 credits; 2-9 credits prorated and any credits over 10 "free").
3. *JBC3 policy* — Graduate and undergraduate figures separately with graduate students paying 120% of the undergraduate rate.

Table 1
Initial Policy Runs

STATE VARIABLES

241 - Total Tuition Revenue

		COLORADO TUITION RUN -- CURRENT POLICY	COLORADO TUITION RUN -- CCHE POLICY	COLORADO TUITION RUN -- JBC1 POLICY
ARAPOHOE	COMMUNITY	255285.00	268596.00	263559.00
DENVER	COMMUNITY	850064.00	888092.00	893312.00
EL PASO	COMMUNITY	379141.00	392005.00	387042.00
LAMAR	COMMUNITY	35825.30	29703.90	44719.60
MORGAN	COMMUNITY	23886.10	26494.40	28025.80
OTERO	COMMUNITY	51496.50	44113.70	63767.80
TRINIDAD	COMMUNITY	123449.00	110821.00	165323.00
ADAMS	FOUR YEAR	445679.00	439062.00	478553.00
FT LEWIS	FOUR YEAR	913951.00	913118.00	942614.00
MESA	FOUR YEAR	399287.00	310442.00	422873.00
METRO	FOUR YEAR	1141080.00	1174010.00	1155820.00
SOUTHERN	FOUR YEAR	833280.00	810449.00	885781.00
UNIV N COLO	FOUR YEAR	1940450.00	1926720.00	2034500.00
WESTERN	FOUR YEAR	559839.00	558581.00	594536.00
COLO STATE	UNIVERSITY	7323180.00	7225590.00	7578360.00
MINES	UNIVERSITY	1135010.00	1133370.00	1245520.00
UC BOULDER	UNIVERSITY	11168500.00	10989100.00	11572200.00
UC CO SPRNG	UNIVERSITY	553644.00	636926.00	563109.00
UC DENVER	UNIVERSITY	1110670.00	1132940.00	1127410.00
		29,243,746	29,010,132	30,447,023
			- .8%	+ 4.0%
			- 233,000	+ 1,203,277

(Note: Totals, percent change and dollar change are hand calculated.)

Table 2

Enrollment and Revenue Measures

MINES UNIVERSITY

1975

	COLORADO TUITION RUN -- CURRENT POLICY	COLORADO TUITION RUN -- CCHE POLICY
PCT RESIDENT REVENUE	31.30	31.26
PCT NONRES REVENUE	68.70	68.74
PCT UG REVENUE	79.57	79.60
PCT GRAD REVENUE	20.43	20.40
PCT RES UG REVENUE	27.61	27.60
PCT RES GRAD REV	3.69	3.66
PCT NONRES UG REV	51.96	52.00
PCT NONRES GRAD REV	16.74	16.74
PCT RESIDENT ENROLL	65.83	65.83
PCT NONRES ENROLL	34.17	34.17
PCT UG ENROLL	82.71	82.71
PCT GRAD ENROLL	17.29	17.29
PCT RES UG ENROLL	57.03	57.03
PCT RES GRAD ENROLL	8.80	8.80
PCT NONRES UG ENROLL	25.68	25.68
PCT NONRES GRD ENROL	8.48	8.48
TOTAL ENROLLMENT	2204.00	2204.00

UC BOULDER UNIVERSITY

1975

	COLORADO TUITION RUN -- CURRENT POLICY	COLORADO TUITION RUN -- CCHE POLICY
PCT RESIDENT REVENUE	30.86	31.19
PCT NONRES REVENUE	69.14	68.81
PCT UG REVENUE	83.61	84.83
PCT GRAD REVENUE	16.39	15.17
PCT RES UG REVENUE	25.96	26.37
PCT RES GRAD REV	4.90	4.82
PCT NONRES UG REV	57.65	58.46
PCT NONRES GRAD REV	11.49	10.35
PCT RESIDENT ENROLL	65.34	65.34
PCT NONRES ENROLL	34.66	34.66
PCT UG ENROLL	79.71	79.71
PCT GRAD ENROLL	20.29	20.29
PCT RES UG ENROLL	51.65	51.65
PCT RES GRAD ENROLL	13.69	13.69
PCT NONRES UG ENROLL	28.05	28.05
PCT NONRES GRD ENROL	6.60	6.60
TOTAL ENROLLMENT	21623.00	21623.00

Table 3

Exception Reports

Exception Report 260

		COLORADO TUITION RUN -- CCHE POLICY	COLORADO TUITION RUN -- JBC1 POLICY
ARAPOHOE	COMMUNITY	0.00*	257.00 *
DENVER	COMMUNITY	0.00	257.00
EL PASO	COMMUNITY	0.00	197.00
LAMAR	COMMUNITY	159.00	257.00
MORGAN	COMMUNITY	0.00	257.00
OTERO	COMMUNITY	0.00	197.00
TRINIDAD	COMMUNITY	159.00	257.00
ADAMS	FOUR YEAR	199.00	197.00
FT LEWIS	FOUR YEAR	199.00	257.00
MESA	FOUR YEAR	176.00	197.00
METRO	FOUR YEAR	199.00	197.00
SOUTHERN	FOUR YEAR	199.00	257.00
UNIV N COLO	FOUR YEAR	199.00	257.00
WESTERN	FOUR YEAR	199.00	197.00
COLO STATE	UNIVERSITY	168.00	197.00
MINES	UNIVERSITY	168.00	257.00
UC BOULDER	UNIVERSITY	199.00	197.00
UC CO SPRNG	UNIVERSITY	237.00	257.00
UC DENVER	UNIVERSITY	231.00	197.00

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		COLORADO TUITION RUN -- CCHE POLICY	COLORADO TUITION RUN -- JBC1 POLICY
ARAPOHOE	COMMUNITY	0.00*	167.00 *
DENVER	COMMUNITY	0.00	167.00
EL PASO	COMMUNITY	0.00	227.00
LAMAR	COMMUNITY	160.00	167.00
MORGAN	COMMUNITY	0.00	167.00
OTERO	COMMUNITY	0.00	227.00
TRINIDAD	COMMUNITY	160.00	167.00
ADAMS	FOUR YEAR	200.00	227.00
FT LEWIS	FOUR YEAR	200.00	167.00
MESA	FOUR YEAR	141.00	227.00
METRO	FOUR YEAR	200.00	227.00
SOUTHERN	FOUR YEAR	201.00	256.00
UNIV N COLO	FOUR YEAR	200.00	167.00
WESTERN	FOUR YEAR	201.00	227.00
COLO STATE	UNIVERSITY	139.00	227.00
MINES	UNIVERSITY	198.00	167.00
UC BOULDER	UNIVERSITY	200.00	227.00
UC CO SPRNG	UNIVERSITY	200.00	167.00
UC DENVER	UNIVERSITY	203.00	227.00

*The number of the student variable type that experienced the largest percentage change in tuition revenue.

Table 4
Comparison Policy Report

STATE VARIABLES

241 - Total Tuition Revenue

		COLORADO TUITION RUN -- CURRENT POLICY	COLORADO TUITION RUN -- JBC1 POLICY	COLORADO TUITION RUN -- JBC2 POLICY	COLORADO TUITION RUN -- JBC3 POLICY
ARAPOHOE	COMMUNITY	255285.00	267897.00	238187.00	255285.00
DENVER	COMMUNITY	850064.00	909745.00	809979.00	850064.00
EL PASO	COMMUNITY	379141.00	391023.00	339872.00	379141.00
LAMAR	COMMUNITY	35825.30	46412.50	44900.10	35825.30
MORGAN	COMMUNITY	23886.10	28588.10	25972.00	23886.10
OTERO	COMMUNITY	51496.50	65968.40	62086.10	51496.50
TRINIDAD	COMMUNITY	123449.00	172082.00	168358.00	123449.00
ADAMS	FOUR YEAR	445679.00	494707.00	465244.00	445679.00
FT LEWIS	FOUR YEAR	913951.00	973075.00	936111.00	913951.00
MESA	FOUR YEAR	399287.00	436326.00	404893.00	399287.00
METRO	FOUR YEAR	1141080.00	1170050.00	1008260.00	1141080.00
SOUTHERN	FOUR YEAR	833280.00	913224.00	839825.00	833280.00
UNIV N COLO	FOUR YEAR	1940450.00	2102490.00	2003140.00	3113190.00
WESTERN	FOUR YEAR	559839.00	616856.00	599407.00	559839.00
COLO STATE	UNIVERSITY	7323180.00	7774850.00	7130330.00	9239360.00
MINES	UNIVERSITY	1135010.00	1298980.00	1270710.00	1648810.00
UC BOULDER	UNIVERSITY	11168500.00	11867300.00	10926700.00	12643900.00
UC CO SPRNG	UNIVERSITY	553644.00	571016.00	536502.00	579294.00
UC DENVER	UNIVERSITY	1110670.00	1138770.00	936999.00	1161740.00

A report comparing these three runs with the current policy for three of the nineteen institutions is shown in Appendix I-E. It is included as a means of demonstrating the output produced by DRM as well as the flexibility of the SPS in combining data bases produced by several runs to produce reports comparing the results.

RESULTS OF THE SPS TUITION MODEL

The results of the testing of the SPS were quite impressive to the staff of the CCHE and the Joint Budget Committee. They were especially pleased with the ability of the SPS to display the impact of each tuition option on residents and non-residents, graduate/undergraduate, part-time/full-time; to show how the impact shifts as the policy alternatives change; and to show the revenue consequence of each option.

The test served as a check on the intuitive sense of CCHE and JBC staff members regarding the impact of various options. In some cases, the SPS demonstrated much larger impacts than intuitively expected.

Without a knowledge of student price response coefficients, it is not possible to anticipate the change in enrollment and enrollment distributions by the categories used. Historical data upon which to base student price-response coefficients were not available at the time, and available national price response coefficients were judged to be not typical enough of Colorado, because of its high out-of-state enrollment, to be useful. On March 15, the Joint Budget Committee's appropriations bill was introduced in the House. It included the first change in tuition policy in a number of years. This change added a surcharge for any credit hours taken over 18 (1/15 full-time rate as currently calculated). This policy was one of those tested with the SPS (discussed in the Report section as JBC2 policy). The SPS results suggested that, if adopted, this policy option would increase revenue slightly without appearing to discourage access to post-secondary education. The SPS results were used and the test was declared to be a successful exercise.

The CCHE staff had extensive experience working with simulation models of various types, including CAMPUS, RRPM, PLANTRAN, and specifically built simulation models. In examining tuition policy alternatives, CCHE staff chose an internally-built modeling system based on a CCHE staff linkage of two other products. The system is identified as EXIR/OMNITAB, and is based upon a data retrieval system entitled EXIR (built by the University of Colorado Taximetrics Laboratory), which permits the integration of data elements; and the OMNITAB system (developed by the National Bureau of Standards) for statistical analysis of data that can be arranged in a matrix format.

The models for objectives a through e (see page 3) used a staff-defined algorithm developed for use with the EXIR/OMNITAB system. A limitation of the OMNITAB system is its linear formulation. It is a calculator approach that manipulates the data to determine the revenue produced from each tested tuition assumption. The model was easy to develop (the EXIR/OMNITAB systems were already operational) and results were provided quickly through the OMNITAB system. However, it was not possible to develop the impact measures which were an essential feature of the SPS model. For example, OMNITAB could define percentage impacts as a variable, but the task of producing and reporting them in an understandable format would be difficult. Finally, OMNITAB had not only a size limitation that restricted the ability to analyze a large model framework, but the inability to run in an optimization mode (like the SPS) to seek out and achieve a goal objective as well.

COSTS OF OMNITAB

Current limitations of the OMNITAB matrix size required that each school be modeled separately. OMNITAB did allow multiple assumptions to be made for each school and results to be stored. A set of control statements was built to execute each of the 19 schools in a delayed sequential submit method, i.e., the jobs were submitted overnight on a low priority basis with the delay built in so that the common files were not destroyed. With this low priority computing time, each run ranged from $3 to $10 per school per assumption depending upon the size of the school. High priority rates were $15 to $50 per school. Thus, for the 19 schools, the model for each assumption cost between $52 and $190 if run overnight at low priority computer time or $285 to $950 if run on an "immediate" basis during the day.

It took ten days to develop the original OMNITAB design (somewhat longer than normal due to the involvement of a staff member who was relatively inexperienced with the OMNITAB system). Each new design or test of a new assumption took approximately one hour to set up.

EVALUATION OF THE SPS

In evaluating the SPS itself, the CCHE staff found that (1) it was easier to use, with the initial training aid of NCHEMS staff, than the internally developed EXIR/OMNITAB system, (2) the ability to change designs in progress was as easy as any models used thus far, (3) the ability to produce measures from variables contained in the design was an extremely valuable feature, (4) the ability to recognize revenue consequences in a tuition model raises possibilities for developing a full financial planning model with expenditure and revenue sides, and (5) the relative cost per run and the ease of turnaround time (namely, the ability to get answers back in a matter of hours or, at most, overnight) was an important feature since policies tend to be open for consideration for only a very short period of time.

Another extension of the SPS which CCHE staff considered is goal-programming optimization. As the tuition model experience leads into financial modeling applications, it should be possible to analyze the consequences of achieving more complex goals, including those with multiple objectives and multiple constraints.

Appendix I-A
Tuition Policy (Discussion Item)

Policies relating to tuition charges are of major interest and importance to students, to institutions of higher education, and to the state because they directly affect matters of access to educational opportunity on one hand, and income to help offset charges on tax-generated funds on the other. The Commission has made several proposals concerning tuition policies and charges in recent years, following analysis of varying practices among the institutions particularly with respect to charges for part-time enrollment. At this time the Commission is making further analyses relating both to the part-time issue and to other possible policies or practices that would serve to increase income available for operating requirements of the system of higher education while also representing equity for students and among institutions.

Any tuition charge can be viewed as an interference with educational access and an inequity to the student who must pay the charge. Without assuming that the present level of charges in Colorado is optimal from the point of view of the student, the institution, or the state, our assessments are directed toward possible improvements in equity, or at least the maintenance of the degree of equity attainable under present policies, while increasing revenues.

We are testing the fiscal impact of policy alternatives relating to several components or aspects of tuition policy, as outlined below. There are educational, equity, political and other implications surrounding all of these alternatives, just as there are in relation to the policies now in effect. Our hope is that given a view of the fiscal impact of alternatives, the relative educational and other advantages and disadvantages of various alternatives can be more fully assessed.

PRINCIPAL ELEMENTS UNDER REVIEW

1. *Number of credits in institution definition of "full-time for tuition purposes."* Table I-A-1 shows, among other things, that definitions of "full-time for tuition purposes" vary as follows: (a) for residents, from 6 to 12; (b) nonresidents, from 1 to 12. When the full-time tuition is pro-rated for part-time students, it is obvious that the per credit charge is much higher in the institution where 6 or 7 credits is full-time than where that number is 12. (Also, of course, in the same circumstances the student taking 9 credits is treated very differently). The Commission had made proposals to provide for uniformity of definition but agreement on a voluntary basis has been lacking and no statutory action has been taken in the matter.

   We are testing the impact of definitions of full-time as follows: (a) residents, at 10 and at 12 credits (assuming the minimum charge for enrollment is for 2 credits); and (b) nonresidents, at 7 credits, or *lower* if the institution chooses a lower number, with a charge of twice the resident rate for enrollment for 2 or 3 credits and proration of the nonresident rate for 4 through 6 credits.

2. *Surcharge for credits enrolled far beyond 18.* Some students enroll for credits far beyond the "normal" 15 or 16. In some programs (e.g., engineering) enrollment for 17 or 18 credits per term is normal. Also, there are positive educational values in encouraging students to take programs that are challenging to them. However, state funding is based on the "FTE" which represents 15 credits per term (45 per academic year on quarter system, 30 on semester system). Students enrolling for, say, 20 credits per term and paying the straight full-time tuition charge therefore derive a substantial subsidy in addition to that provied by the policy of charging residents 25% of prior year educational and general cost (20% in community colleges).

Table I-A-1
Part-Time/Full-Time Term Rates

	Resident				Non-Resident			
	Part-Time Per Credit	Full-Time No. of Credits	Charge Per Term	Term Charge Full-Time Hours	Part-Time Per Credit	Full-Time No. of Credits	Charge Per Term	Term Charge Full-Time Hours
Adams State College	18.00	7	123.00	17.57	25.00	7	492.00	70.28
Colorado School of Mines	27.00[1]	10	266.00	26.60	106.33[1]	10	1,062.00	106.20
Colorado State University	40.00[1]	6	238.00	39.66	79.00[1]	6	951.00	158.50
CSU-Veterinary Medicine								
Fort Lewis College	20.00	9	163.50	18.16	75.00	9	653.50	72.61
Mesa College	15.00	9	127.00	14.11	35.00	9	507.00	56.33
Metropolitan State College	11.50	10	121.00	12.10	24.00	10	406.00	40.60
Southern Colorado State College	18.00	7	127.00	18.14	25.00	7	509.00	72.71
University of Colorado								
-Boulder	27.00[1]	10	265.50	26.55	1,061.50	1	1,061.50	1,061.50
-Colorado Springs	16.00	11	180.00	16.36	36.00	11	717.00	65.18
-Denver	16.00	10	159.50	15.95	37.00	7	638.00	91.14
-Medical Center-Medical	N/A	N/A	1,316.00[2]	--	N/A	N/A	5,263.00[2]	--
-Dental	N/A	N/A	10,634.00[3,2]	--	N/A	N/A	10,634.00[2]	--
-Nursing	35.00[1]	11	385.00	35.00	420.00[4]	4	1,540.00	385.00
-Grad. Aux.	23.00[1]	11	257.00	23.36	280.00[4]	4	1,027.00	256.75
University of Northern Colorado	17.00	7	117.00	16.71	34.00	7	465.00	66.43
Western State College	17.00	7	107.00	15.28	22.00	7	428.00	61.14
Arapahoe Community College	6.60	12	79.00	6.58	33.00	12	396.00	33.00
Community College of Denver	6.60	12	79.00		32.00	12	385.00	32.08
El Paso Community College	6.60	12	79.00		27.75	12	332.00	27.66
Lamar Community College	6.60	12	79.00		26.00	12	313.00	26.08
Morgan Community College	6.60	12	79.00		40.00	12	480.00	40.00
Otero Junior College	6.60	12	79.00		26.00	12	313.00	26.08
Trinidad State Junior College	6.60	12	79.00		26.00	12	313.00	26.08

(1) 3 credit hours/term minimum charge
(2) Charge shown is per academic year
(3) Cash outlay of $1,329
(4) Students enrolled 3 hours or less pay amount shown per term

We are testing the results of a policy that, for each credit beyond 18, would add to the full-time tuition charge the pro-rated amount per credit charged to part-time students.

3. *Differentiations among certain categories of students.* Currently in Colorado, except in a limited number of medical-related professions, all enrolled students pay the tuition charge set for the entire institution in which they are enrolled. No institution in the country that we are aware of relates tuition to program cost, but many now differentiate tuition charges according to whether the student is an undergraduate or a graduate student. (A few also differentiate between lower and upper level undergraduates.) Policy varies widely; some states charge graduates *less* than undergraduates, though more reverse this, apparently on the grounds that on the average, graduate programming is more costly than undergraduate.

   We are testing the fiscal impact of a policy that would differentiate undergraduate and graduate students and charge graduates *120%* of the undergraduate rate. We will also, if our information base permits, test a policy that would charge "special students" (those not enrolled in a degree program) at the nonresident rate.

4. *Change in components in the cost base.* For several years, tuition charges have been related to "educational and general cost" of the prior year. "Educational and general cost" includes most costs associated directly and indirectly with the instructional program but excludes capital outlay, rentals, inter-collegiate athletics, student aid and some other categories. Moreover, no allocation is made to the cost base to reflect capital construction (facilities) cost. We are looking at the impact of changes that would increase the cost base by varying amounts, especially for nonresident students.

5. *Increase the percentage of cost to be paid by the student.* Currently, resident students pay 20% of cost (community colleges) or 25% (four-year institutions). We are calculating fiscal results of an increase of 2% (which may readily be modified into other percentage amounts that any agency might wish to assess).

Many of the implications of the possible changes in these conditions or components of policy can be foreseen in advance of having specific information about the fiscal impact of such changes.

Appendix I-B
Tuition Variations To Be Simulated/Tested

Based on the tuition policy discussion item (Appendix I-A) prepared by CCHE staff for presentation to the Colorado Commissioners of Higher Education, the CCHE staff in conjunction with staff of the Joint Budget Committee (JBC) prepared a "laundry list" of possible tuition variations to be simulated/tested. In actuality, not all of the alternatives were tested due, in part, to time limitations. In addition, several not included as part of the list were proposed and tested. The runs that were made are more fully discussed in the Report section of the case study. The following is the "laundry list" as prepared by CCHE and JBC staff.

1. Full-time is 10 credits, minimum charge is for 2 credits; 2-9 credits are prorated (1/10 per credit); credits over 10 are "free". (This is in essence our current policy with "full-time" standardized at 10 credits).
2. Same as #1 except student pays the per credit rate for each credit over 15.
3. Same as #1 except student pays a "surcharge" at 50% of the per credit rate for credits over 15.
4. Current policy is continued for each school, except student pays a "surcharge" of 50% of the per credit rate for credits over 15.
5. Cost base is redefined to include capital outlay and intercollegiate athletics (student aid is not included because of impact on tuition in what should be "low cost institutions").
6. No change in present policy; compute income from a 1% increase in the ratio of tuition to the cost base (i.e., 26/21 instead of 25/20; the objective is to provide numbers which can be multiplied to provide the results for any assumption about a change in the ratio of tuition to cost base).
7. Graduate and special (i.e., not enrolled in degree program) students pay 27.5% of base (rather than 25%). (This policy would increase tuition for resident graduate and special students by 10%.)
8. Charge per credit @ 1/15 of "full-time tuition" for each credit taken, regardless of number.
9. Same, except for credits @ 16 and over, charge 150% of per credit rate.

Nonresident Students:

1. Full-time is 7 credits, except at UC-B where it is 1 credit; minimum charge is for 2 credits; 2-6 credits are at *double* the resident rate. (This is in essence the current policy, with "full-time" standardized at 7 credits and 2-6 credits charged 2x rather than 4x the resident rate.)
2. Same, except student pays 1/15 of full-time charge for each credit over 15.
3. Current policy is continued for each school except student pays 1/15 of full-time (term) charge for each credit over 15 (in addition to full-time charge).
4. Cost base is redefined to include capital outlay, intercollegiate athletics.

Appendix I-C
Data Collection Format

CO[illegible]RADO COMMISSION ON HIGHER EDUCATION
Survey of Enrollments By Credit Hours Taken

Fall Term 1974

Full-Ti[illegible]12 or more hours

Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6	Col. 7	Col. 8	Col. 9	Col. 10	Col. 11	Col. 12	Col. 13
	Head Count Students											
Credit Hours Taken	Resident			Non-Resident			Credit Hours		1974 Tuition Rates		Tuition Income	
	UG	Grad	Total	UG	Grad	Total	Resident	Non-Resident	Resident	Non-Resident	Resident	Non-Resident
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												
11												
12												
13												
14												
15												
16												
17												
18												
19												
20												
21												
22												
23												
24												
25												
26												
27												
28												
29												
30 +												
Totals												

Appendix I-D
Design Equations

The following is a listing of the computer code for the Colorado pilot-test design. To enable the less technically inclined user to understand the computations, the five tuition formulas for the four breakpoints (discussed in the Design section of the case study) have been extrapolated from the code and are listed separately. Figure 3 in the text further illustrates the tuition formulas in conjunction with the breakpoints.

Tuition Formulas

EQUATION ONE AND TWO — differentiated by the user determined breakpoints and data values.

Tuition by Number of Credit Hours, Level, Residence = Fixed Administrative Processing Charge + Additional Fixed Administrative Charge by Level and Residence + Number of Semester Credit Hours * (Adjustment to Percent of Cost Per Credit Hour By Each Breakpoint * Percent of Cost Per Credit Hour By Level and Residence * Cost per Credit Hour + Incremental Charge Per Credit Hour By Breakpoint and Level)

EQUATION THREE AND FOUR — differentiated by the user determined breakpoints and data values.

Tuition by Number of Credit Hours, Level, Residence = Fixed Administrative Processing Charge + Additional Fixed Administrative Charge by Level and Residence + Number of Semester Credit Hours * (Adjustment to Percent of Cost Per Credit Hour By Each Breakpoint * Percent of Cost Per Credit Hour By Level and Residence * Cost per Credit Hour)

+ (Number of Semester Credit Hours − Number of Credit Hours At Each Breakpoint) * Incremental Charge Per Credit Hour By Breakpoint And Level

EQUATION FIVE

Tuition by Number of Credit Hours, Level, Residence = Fixed Administrative Processing Charge + Additional Fixed Administrative Charge by Level and Residence + Number of Credit Hours At Each Breakpoint * (Percent of Cost Per Credit Hour * Cost per Credit Hour)

+ (Number of Semester Credit Hours − Number of Credit Hours At Each Breakpoint) * (Adjustment to Percent of Cost Per Credit Hour By Each Breakpoint * Percent of Cost Per Credit Hour By Level and Residence * Cost per Credit Hour + Incremental Charge Per Credit Hour By Breakpoint And Level)

Computer Code Listing

```
      SUBROUTINE STATE (J,DN,S,D,C,E,K,NS,ND,NC,NE,NK,NY,NDSGN)
C
      REAL K
      DIMENSION DN(ND),S(NS),D(ND,NY),C(NC,NY),E(NE,NY),K(NK,NY)
C
C D(1,J) THRU D(120,J) -- ADJUSTED HEAD COUNT STUDENTS FOR 120
C     STUDENT TYPES AS DEFINED BY CREDIT HOUR (CH), LEVEL,
C     AND RESIDENCE.  THE INDEXES ARE
C       1-30 FOR UNDERGRADUATE RESIDENT
C       31-60 FOR GRADUATE RESIDENT
C       61-90 FOR UNDERGRADUATE NON-RESIDENT
C       91-120 FOR GRADUATE NON-RESIDENT.
C
C D(121,J) THRU D(240,J) -- TUITION CHARGE PER HEAD COUNT STUDENT
C     FOR EACH OF THE 120 STUDENT TYPES
C
C D(241,J) -- TOTAL TUITION REVENUE
C
C C(1,J) THRU C(4,J) -- PERCENT OF COST PER CREDIT HOUR
C     BY LEVEL AND RESIDENCE
C
C C(5,J) THRU C(9,J) -- INCREMENTAL CHARGE PER CREDIT HOUR
C     FOR UNDERGRADUATES BY BREAKPOINT
C
C C(10,J) -- FIXED ADMINISTRATIVE PROCESSING CHARGE
C
C C(11,J) THRU C(15,J) -- ADJUSTMENT TO PERCENT OF COST PER
C     CREDIT HOUR BY BREAKPOINT
C
C C(16,J) THRU C(20,J) -- INCREMENTAL CHARGE PER CREDIT HOUR
C     FOR GRADUATES BY BREAKPOINT
C
C C(21,J) THRU C(24,J) -- ADDITIONAL FIXED ADMINSITRATIVE CHARGE
C     BY LEVEL AND RESIDENCE
C
C E(1,J) THRU E(120,J) -- FORECASTED HEAD COUNT STUDENTS FOR
C     EACH OF THE 120 STUDENT TYPES
C
C K(1,J) THRU K(4,J) -- BREAKPOINTS ON TUITION CHARGES USED TO
C     DETERMINE WHICH OF THE FIVE TUITION EQUATIONS ARE USED
C     FOR THE RESIDENT STUDENTS
C
C K(5,J) -- COST PER CREDIT HOUR
C
C K(6,J) THRU K(9,J) -- BREAKPOINTS ON TUITION CHARGES USED TO
C     DETERMINE WHICH OF THE FIVE TUITION EQUATIONS ARE USED
C     FOR THE NON-RESIDENT STUDENTS
C
C THE FOLLOWING FORMULA IS USED TO CALCULATE D(1,J) THRU
C D(120,J) BY USING THE FORECASTED HEAD COUNT
C STUDENTS.  A REVISED DESIGN WOULD INCLUDE STUDENT RESPONSE TO
C PRICE CHANGES TO MODIFY THE FORECAST.
C
      DO 10 I = 1, 120
        DN(I) = E(I,J)
10    CONTINUE
C
C THE FOLLOWING FORMULAS CALCULATE THE TUITION CHARGES
C FOR EACH OF THE 120 STUDENT TYPES.  THE VARIABLE IS IS USED
C TO REPRESENT EACH STUDENT TYPE.
C
      IS = 0
```

```
C
C LOOP OVER EACH RESIDENCE CATEGORY
C   IR = 1 FOR RESIDENT
C      = 2 FOR NON-RESIDENT
C
      DO 100 IR = 1, 2
C
C     SET I1, I2, I3, I4 TO BREAKPOINT VALUES DEPENDING ON
C     RESIDENCE
C
        IF(IR .EQ. 2) GO TO 15
          I1 = K(1,J)
          I2 = K(2,J)
          I3 = K(3,J)
          I4 = K(4,J)
          GO TO 17
15      CONTINUE
          I1 = K(6,J)
          I2 = K(7,J)
          I3 = K(8,J)
          I4 = K(9,J)
17      CONTINUE
C
C     LOOP OVER EACH LEVEL CATEGORY
C       IL = 1 FOR UNDERGRADUATE
C          = 2 FOR GRADUATE
C
        DO 100 IL = 1, 2
C
C       LOOP OVER EACH CREDIT HOUR CATEGORY
C
          DO 100 IC = 1, 30
            IS = IS + 1
C         II IS INDEX FOR C1 --- C4
            II = IL + 2*(IR/2)
C         JJ IS INDEX FOR C21 --- C24
            JJ = 20 + IL + 2*(IR/2)
C         IK IS ADDITIVE FACTOR FOR C5 --- C9 OR C16 --- C20
            IK = 0
            IF(IL .EQ. 2) IK = 11
C
C         TUITION CALCULATION EQUATIONS FOR EACH BREAKPOINT
C
            IF(IC .GT. I1) GO TO 20
C         EQUATION ONE
              DN(IS) = C(10,J) + C(JJ,J) +
                IC*(C(11,J)*C(II,J)*K(5,J) + C(IK+5,J))
              GO TO 100
C
20          CONTINUE
            IF(IC .GT. I2) GO TO 30
C         EQUATION TWO
              DN(IS) = C(10,J) + C(JJ,J) +
                IC*(C(12,J)*C(II,J)*K(5,J) + C(IK+6,J))
              GO TO 100
C
30          CONTINUE
            IF(IC .GT. I3) GO TO 40
C         EQUATION THREE
              DN(IS) = C(10,J) + C(JJ,J) +
                IC*(C(13,J)*C(II,J)*K(5,J)) + (IC-I2)*C(IK+7,J)
              GO TO 100
```

```
C
40          CONTINUE
            IF(IC .GT. I4) GO TO 50
C         EQUATION FOUR
              DN(IS) = C(10,J) + C(JJ,J) +
                IC*(C(14,J)*C(II,J)*K(5,J)) + (IC-I3)*C(IK+8,J)
              GO TO 100
C
50          CONTINUE
C         EQUATION FIVE
              DN(IS) = C(10,J) + C(JJ,J) +
                I4*(C(II,J)*K(5,J)) +
                (IC-I4)*(C(15,J)*C(II,J)*K(5,J) + C(IK+9,J))
C
100   CONTINUE
C
C THE FOLLOWING FORMULA CALCULATES THE TOTAL TUITION REVENUE
      DN(241) = 0.0
      DO 110 I = 1, 120
        II = I + 120
        DN(241) = DN(241) + DN(I)*DN(II)
110   CONTINUE
C
      RETURN
      END
      SUBROUTINE TERMS (J,R,S,D,C,E,K,NS,ND,NC,NE,NK,NT,NYD,NY,NDSGN)
C
      REAL K
      DIMENSION R(NT),S(NS),D(ND,NYD),C(NC,NY),E(NE,NY),K(NK,NY)
C
C THERE ARE NO TERM VARIABLES IN THIS DESIGN
C
      RETURN
      END
      SUBROUTINE MSRS (J,M,S,D,C,E,K,NS,ND,NC,NE,NK,NM,NYD,NY,NDSGN)
C
      REAL K,M
      DIMENSION M(NM),S(NS),D(ND,NYD),C(NC,NY),E(NE,NY),K(NK,NY)
C
C THE FOLLOWING MEASURES EQUATIONS CALCULATE THE TUITION
C REVENUE FOR EACH OF THE 120 TYPES OF STUDENTS.
C
          DO 80 I=1,120
          II=I+120
          M(I)=D(I,J+1)*D(II,J+1)
 80       CONTINUE
C
C THE FOLLOWING MEASURE CALCULATES THE PERCENT TUITION
C REVENUE COMING FROM (1)RESIDENT, (2)NONRESIDENT, (3)
C UNDERGRADUATE, (4)GRADUATE, (5)RESIDENT UNDERGRADUATE,
C (6)RESIDENT GRADUATE, (7)NONRESIDENT UNDERGRADUATE,
C (8)NONRESIDENT GRADUATE.
C
          M(121)=0
          M(129)=0
          DO 90 I=1,60
          II=I+120
          M(121)=M(121)+D(I,J+1)*D(II,J+1)
          M(129)=M(129)+D(I,J+1)
 90       CONTINUE
          M(137)=M(129)
C
```

```
C RESIDENT TUITION REVENUE/TOTAL REVENUE
          M(121)=(M(121)/D(241,J+1))*100.0
          M(130)=0
          M(122)=0
          DO 91 I=61,120
          II=I+120
          M(122)=M(122)+D(I,J+1)*D(II,J+1)
          M(130)=M(130)+D(I,J+1)
 91       CONTINUE
          M(137)=M(137)+M(130)
C
          M(129)=(M(129)/M(137))*100.0
C NONRESIDENT/TOTAL
          M(122)=(M(122)/D(241,J+1))*100.0
          M(130)=(M(130)/M(137))*100.0
          M(123)=0
          M(131)=0
          DO 92 I=1,30
          II=I+120
          IJ=I+60
          JJ=IJ+120
          M(123)=M(123)+D(I,J+1)*D(II,J+1)+D(IJ,J+1)*D(JJ,J+1)
          M(131)=M(131)+D(I,J+1)+D(IJ,J+1)
 92       CONTINUE
C
C UNDERGRADUATE/TOTAL
          M(123)=(M(123)/D(241,J+1))*100.0
          M(131)=(M(131)/M(137))*100.0
          M(124)=0
          M(132)=0
          DO 93 I=31,60
          II=I+120
          IJ=I+60
          JJ=IJ+120
          M(124)=M(124)+D(I,J+1)*D(II,J+1)+D(IJ,J+1)*D(JJ,J+1)
          M(132)=M(132)+D(I,J+1)+D(IJ,J+1)
 93       CONTINUE
C
C GRADUATE/TOTAL
          M(124)=(M(124)/D(241,J+1))*100.0
          M(132)=(M(132)/M(137))*100.0
          M(125)=0
          M(133)=0
          DO 94 I=1,30
          II=I+120
          M(125)=M(125)+D(I,J+1)*D(II,J+1)
          M(133)=M(133)+D(I,J+1)
 94       CONTINUE
C
C RESIDENT UNDERGRADUATE/TOTAL
          M(125)=(M(125)/D(241,J+1))*100.0
          M(133)=(M(133)/M(137))*100.0
          M(126)=0
          M(134)=0
          DO 95 I=31,60
          II=I+120
          M(126)=M(126)+D(I,J+1)*D(II,J+1)
          M(134)=M(134)+D(I,J+1)
 95       CONTINUE
C
C
C
```

```
C RESIDENT GRADUATE/TOTAL
          M(126)=(M(126)/D(241,J+1))*100.0
          M(134)=(M(134)/M(137))*100.0
          M(127)=0
          M(135)=0
          DO 96 I=61,90
          II=I+120
          M(127)=M(127)+D(I,J+1)*D(II,J+1)
          M(135)=M(135)+D(I,J+1)
 96       CONTINUE
C
C NON-RESIDENT UNDERGRADUATE/TOTAL
          M(127)=(M(127)/D(241,J+1))*100.0
          M(135)=(M(135)/M(137))*100.0
          M(128)=0
          M(136)=0
          DO 97 I=91,120
          II=I+120
          M(128)=M(128)+D(I,J+1)*D(II,J+1)
          M(136)=M(136)+D(I,J+1)
 97       CONTINUE
C
C NON-RESIDENT GRADUATE/TOTAL
          M(128)=(M(128)/D(241,J+1))*100.0
          M(136)=(M(136)/M(137))*100.0
C M(138) THRU M(257) STORE THE PERCENT CHANGE
C IN TUITION FOR 120 STUDENT TYPES. M(258) STORES THE
C NUMBER HAVING A CHANGE GREATER THAN K(10,J) PERCENT,
C AND M(259) THRU M(262) CONTAIN THE INDEXES OF THE
C FOUR VARIABLES THAT VARY THE MOST.
          M(258)=0
          M(259)=0
          M(260)=0
          M(261)=0
          M(262)=0
          DO 130 I=138,257
          II=I-17
          IF (D(II,J).EQ.0) GO TO 110
          M(I)=100.0*((D(II,J+1)-D(II,J))/D(II,J))
          GO TO 115
 110      M(I)=100.0
 115      IF (ABS(M(I)).LT.K(10,J)) GO TO 120
          M(258)=M(258)+1.0
          IJ=I
          DO 118 IL=259,262
          IF (M(IL).GT.0.0) GO TO 117
          M(IL)=IJ
          GO TO 120
 117      IK=M(IL)
          IF(ABS(M(IK)).GE.ABS(M(IJ))) GO TO 118
          M(IL)=IJ
          IJ=IK
 118      CONTINUE
 120      CONTINUE
 130      CONTINUE
C
      RETURN
      END
```

Appendix I-E
Revenue Measures

Equations to calculate revenue and enrollment measures were included in the Colorado design. It was therefore possible to retrieve percentage figures for the percent of revenue generated by the various student categories as broken out by resident/non-resident and undergraduate/graduate in addition to the actual tuition figures. The following DRM report details the revenue measures for four of the policy alternatives tested (the Report section of the case study outlines what each alternative was) for three institutions. It is included as a means of demonstrating the output produced by DRM as well as the flexibility of the SPS in combining data bases produced by several runs to produce reports comparing the results.

Revenue Measures

UC BOULDER UNIVERSITY

1975

	COLORADO TUITION RUN -- CURRENT POLICY	COLORADO TUITION RUN -- JBC1 POLICY	COLORADO TUITION RUN -- JBC2 POLICY	COLORADO TUITION RUN -- JBC3 POLICY
PCT RESIDENT REVENUE	30.86	30.65	30.49	28.56
PCT NONRES REVENUE	69.14	69.35	69.51	71.44
PCT UG REVENUE	83.61	84.42	88.04	67.74
PCT GRAD REVENUE	16.39	15.58	11.96	32.26
PCT RES UG REVENUE	25.96	25.99	26.69	21.08
PCT RES GRAD REV	4.90	4.65	3.80	7.48
PCT NONRES UG REV	57.65	58.42	61.35	46.66
PCT NONRES GRAD REV	11.49	10.93	8.16	24.78

UC CO SPRNG UNIVERSITY

1975

	COLORADO TUITION RUN -- CURRENT POLICY	COLORADO TUITION RUN -- JBC1 POLICY	COLORADO TUITION RUN -- JBC2 POLICY	COLORADO TUITION RUN -- JBC3 POLICY
PCT RESIDENT REVENUE	67.16	67.05	61.79	67.14
PCT NONRES REVENUE	32.84	32.95	38.21	32.86
PCT UG REVENUE	75.40	76.00	75.75	74.49
PCT GRAD REVENUE	24.60	24.00	24.25	25.51
PCT RES UG REVENUE	51.74	52.02	49.40	51.12
PCT RES GRAD REV	15.42	15.03	12.39	16.02
PCT NONRES UG REV	23.66	23.98	26.35	23.37
PCT NONRES GRAD REV	9.18	8.97	11.86	9.50

UC DENVER UNIVERSITY

1975

	COLORADO TUITION RUN -- CURRENT POLICY	COLORADO TUITION RUN -- JBC1 POLICY	COLORADO TUITION RUN -- JBC2 POLICY	COLORADO TUITION RUN -- JBC3 POLICY
PCT RESIDENT REVENUE	77.74	77.38	74.88	75.92
PCT NONRES REVENUE	22.26	22.62	25.12	24.08
PCT UG REVENUE	71.89	72.39	74.85	67.46
PCT GRAD REVENUE	28.11	27.61	25.15	32.54
PCT RES UG REVENUE	56.89	56.95	57.58	53.45
PCT RES GRAD REV	20.85	20.43	17.30	22.48
PCT NONRES UG REV	15.01	15.45	17.27	14.02
PCT NONRES GRAD REV	7.25	7.18	7.85	10.06

Chapter III

New York Pilot Test Design

INTRODUCTION

The pilot-test of the SPS in New York was conducted by the Board of Regents of the University of the State of New York (the State Education Department), which serves as the coordinating and supervisory agency for all levels of education, public and private, including adult and vocational education. The Board has statutory responsibility for planning and coordinating all segments of postsecondary education.

PROBLEM IDENTIFICATION

Demands for information and accountability have been increasing for higher education in recent years. New York is no exception. The prospect of declining enrollments in the 1980's provides incentives for better information and better tools to support state-level planning and policy formulation. This has led New York to develop information systems and analytical tools to improve understanding of higher education and how it operates. However, recent developments in data processing and quantitative analysis techniques have led New York to look for new tools to help planners and policy makers concerned with postsecondary education in New York State to make decisions and allocate resources more effectively.

The Policy Analysis and Planning Project was established by the New York State Education Department in 1975 to address this topic. This report describes an experimental quantitative model developed under the auspices of this project for analyzing state-level financing strategies for higher education utilizing the State Planning System (SPS) computer software and optimization algorithms.*

OBJECTIVES

The primary objective of the project was to evaluate the potential of large-scale quantitative models in the actual planning process and to enable the Board of Regents and others to evaluate policies, make decisions, and allocate resources more effectively.

Specifically, it was designed to study postsecondary education interactions among students, institutions, and State government, with particular attention to different financial support strategies and tuition policies.

Among the research issues addressed in the project were (1) the feasibility of developing relevant policy measures in sufficient detail to be useful in the policy making process, and (2) whether policy makers will trust these kinds of models and the data required for their operation.

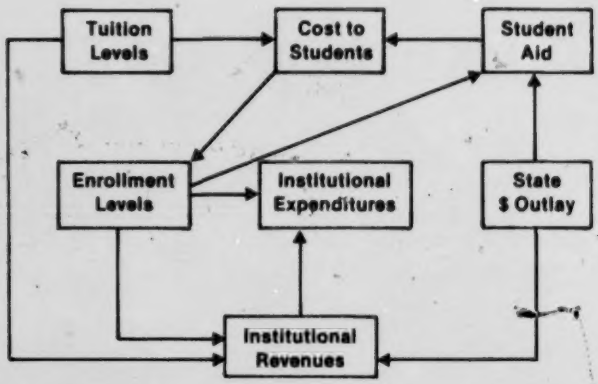
DESIGN

A very simple representation of the basic design is shown in Figure 1. It involves seven major components: tuition levels, cost to students, student aid, enrollment levels, institutional expenditures, state outlay, and institutional revenues. The arrows in the figure indicate in a qualitative sense the interrelationships and flows that exist among the components.

The Financial Planning Model permi[illegible]he study of the interactions among all seven [illegible] these basic components in response to such things as changes in tuition levels, new enrollment projections, and

*The full report, ***State Financial Planning Model, An Experimental Tool for Studying State-Level Strategies for Financing Higher Education in New York State,*** is available in limited quantities from the Office of Postsecondary Research, Information Systems and Institutional Aid, Paul Wing, Coordinator, New York State Education Department, 99 Washington Avenue, Albany, New York 12234.

Figure 1
Primary Components of the Policy Analysis and Planning Model



different state aid formulas. There have been many studies of each of the seven individual components of this model in New York and elsewhere. There have been a few that deal with several of them together, but no previous model has analyzed student demand, institutional expenditures, and state appropriations in the same comprehensive formulation. This is an extremely important feature since it does begin to reflect the complexity of the actual environment facing postsecondary planners and policy makers.

Figure 1 is not sufficiently detailed and specific to serve as the basis for a quantitative model. Each of the seven components must be augmented and made more explicit to reflect actual situations in New York State and to suggest the specific quantitative relationshps and parameters that must be incorporated into the design. Figure 2 takes this next step and makes more clear the nature of the model. It specifies the kinds of programs, activities, and relationships to be studied, and it paves the way for developing specific quantitative relationships and compiling appropriate data. Each of the major components is described briefly in Appendix III-A to indicate the basic relationships and calculations that are involved and to suggest how some of the parts of Figure 2 are linked together. The specific parameters and equations used to transfer this schematic diagram into an actual quantitative model are shown in Appendix III-B.

The chosen design is particularly well suited to the analysis of several types of questions:

1. What would be the impact of a change in tuition in one or more institutional sectors?
2. What would be the financial impact of different enrollment levels in future years?
3. What would be the impact of different award maximums for the State's student aid program (i.e., the Tuition Assistance Program)?
4. What would be the impact of changing the award levels for the State's aid program for independent institutions (i.e., the Bundy Aid Program)?

Certain other questions can also be answered although changes in the design would be required to deal with them. The current version of the model incorporates features that permit tuition levels to be linked directly to institutional expenditure patterns. This required significant modifications to the basic model that was developed initially.

Estimation of many of the parameters used in the model was an easy task. For some, however, significant analytical effort was required. In some cases, this involved identification of data items not usually collected, location of sources for these items, compilation of small data bases, and statistical analysis and manipulation. Appendix III-C indicates some of the data-related effort that was required.

DATA

Some of the basic data categories used in the design included enrollments, institutional finances, State outlays for education, State aid programs for postsecondary education, and the major institutional sectors in the State. Many of the data elements used in the study were actual figures collected by the State Education Department as maintained in the Higher Education Data System in the Office of Postsecondary Research, Information Systems and Institutional Aid. The Regent's Statewide Plan for Postsecondary Education for 1976 provided many of the projected figures for use in the model. Other sources for data were: *The State Aided Colleges; Financial Profiles 1969-73* (NYSED, March 1974), and *The Higher Educational System of New York State* (NYSED, March 1976).

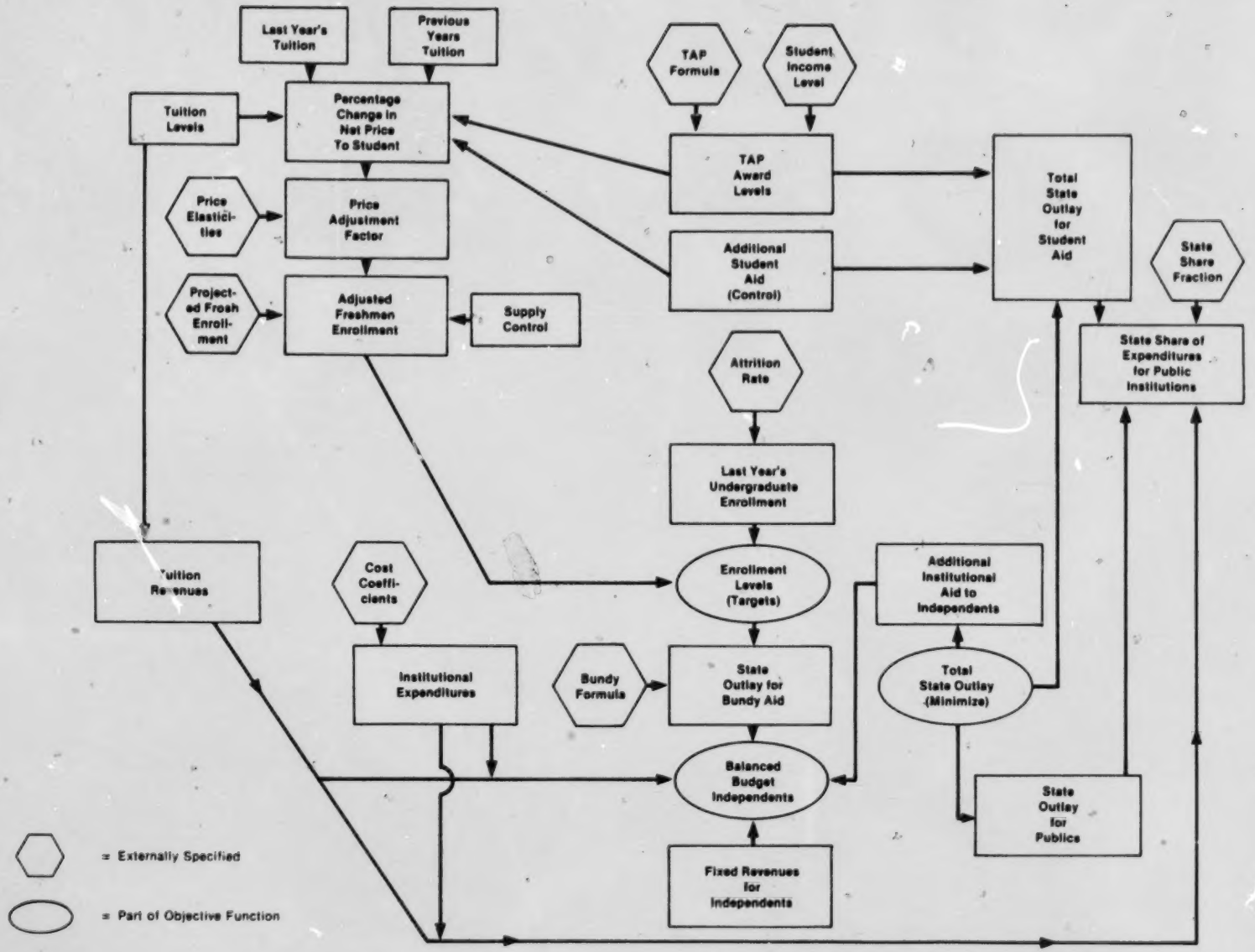


Figure 2
Schematic Representation of the Model

Although data collection and preparation did require significant effort, it would be misleading to say that this effort was relevant only to the model development. It also had several spinoff benefits. It led to improved understanding of a number of aspects of higher education; it identified areas in which improved data collection would be appropriate; and it strengthened the informal communication network that exists between analysts and data providers in the State.

VALIDATION/RUNS

The major work on validating the model was done by the project staff. Most of this effort was devoted to ensuring that the numbers produced by the model were reasonable and realistic. Some of this work involved the addition of new parameters and equations required to make the model reflect actual procedures and relationships more accurately. Some was related to inaccuracies and discrepancies in input data because different sources of data were required in many cases. And some was related to the multi-criteria optimization feature of the model, which occasionally required "tuning" (via adjustments in the targets and tolerances in the objective function).

The project advisory committee also played a role in validating the model, although its impact was less direct. It met several times to review the design of the model, advise on data sources, review the numerical results, and comment on the relevance of the model to state-level planning. The representatives of the institutional sectors were most helpful in pointing out parts of the model that needed additional work.

Three separate questions were identified for exploration using this model:

1. What is the impact of higher education enrollments and finances of the new tuition policies that went into effect in Fall 1976?
2. What will be the impact of the new legislated Bundy Aid formula?
3. What would be the impact of the new higher education financing strategies suggested in the 1976 Regents Tentative Statewide Plan?

The first two of these questions were easy to address requiring changes in only a few of the externally specified coefficients related to tuition levels and Bundy Aid awards.

The third question was more difficult, but the aspects of the Regents proposals related to 4-year institutions could be examined without too much difficulty. It was necessary to add a handful of new equations linking public tuition levels and state aid to the private institutions to SUNY expenditures. It was also necessary to add an inflation factor to all the expenditure formulas to bring the model into line with current expectations. The financing proposals for the 2-year institutions cannot be addressed without extensive additions to the model because of the complicated local charge-back system.

The general procedure followed in applying the model was to establish a benchmark run against which subsequent runs could be compared. The benchmark run reflects the continuation of 1975 policies. Subsequent runs are the result of changes in the design that are introduced and examined one at a time so that their effects on enrollments, expenditures, and student costs could be determined. Examining the incremental effect of one given policy run to a benchmark run establishes a controlled experiment; the effect of the policy is isolated. In such comparisons minor inaccuracies in the parameter estimates generally cancel out, increasing the utility of the model.

Four basic runs were conducted and compared to the benchmark run. Three of them were experimental runs for the three policy questions identified (determining the effect of public sector tuition and increases in Bundy aid for the independent sector on state level expenditures; the financial situation in the independent sector, enrollments, and student costs; and examining the impact of the proposed financing strategies of the 1976 Regents Tentative Statewide Plan) while the fourth tested the sensitivity of the design to changes in the rate of inflation. In fact, many more than four runs were made although most of them are not referred to here. Some were failures, but many were interesting in their own right and useful in suggesting further adjustments for the model. It was encouraging to note that the need for repeated runs does diminish with experience in using the model.

The results of the runs in critical areas such as level of state expenditures, budgetary deficits, and sector enrollment for the most part seem reasonable and defensible. For that reason it is now possible

to say that, to the extent that any quantitative model can be said to reflect reality, this planning and policy development tool is ready for serious consideration for use in actual policy development and evaluation situations.

EVALUATION OF THE SPS

In developing the Financial Planning Model the State Education Department built heavily on computer software developed by the National Center for Higher Education Management Systems (NCHEMS). This software, which was originally referred to as the State Postsecondary Education Planning Model, is now called the State Planning System (SPS).

The SPS software in general was very effective. In the New York pilot test activities the second version of the software was installed and used on two different computer systems, General Electric Time-Sharing Services and a UNIVAC 1110 on the State University of New York at Albany campus. In both instances the software worked well, although the billing algorithm of the GE system made the model very expensive to operate in the optimization mode.

The SPS software is sufficiently flexible to accommodate all the desired relationships included in the New York State model. This is not to say that the task was a simple one. But the major difficulties were not related to the software; they were related to coordinating desired relationships with available data and current knowledge.

Because of the complexity of the Department's model, some difficulties were encountered in obtaining satisfactory initial runs. Tolerances and weights in the objective function could not be left to chance; some simple analyses had to be performed. The procedures in the manuals were sufficient to get them in the right "ballpark."

The data handling and report generating capabilities of the software are adequate, much better than in other quantitative modeling packages. Problems were encountered in the New York State application because we were not sure initially what output reports were desirable. Once these decisions were made, however, there were no serious problems encountered in generating appropriate output reports. Labels and names could be added to reports to make them readily usable.

As multi-criteria non-linear optimization models go, the planning model is enormous. Each iteration through the algorithm involves thousands of calculations. It appears that the optimization algorithm provided by NCHEMS is significantly faster than others that have been available in the past.

LOGISTICS AND RESOURCES

The entire project to develop the model, compile the necessary input data, pilot-test the SPS software, and prepare the final reports took approximately two years and cost approximately $150,000. This includes staff time, computer costs, meeting costs, and all other expenses. The task could be replicated today for half that, with most of the resources required for data compilation and preparation.

An effort was made to determine the minimum skill levels required to carry out the development of the model. Initially, a Ph.D. in quantitative economics oversaw the project; subsequently, a change was made to a B.S.-plus in operations research with part-time assistance from a computer programmer and review and guidance by a Ph.D. in operations research. This latter arrangement would probably be the minimum requirement for the particular model developed in New York State. Less sophisticated applications of the SPS might be managed by a person with a technical B.S. and some relevant experience.

The model, as it now exists, costs between $10 and $20 for a single run; and it takes between five and 50 runs to analyze a particular policy question, depending on how many significant changes are made in the structure of the model. The model could also be adapted to run in the simulation mode, which would require external specification of most of the control variables. If this were done, the cost per run would drop to $2 or less. Some experiments of this type are now being planned.

Overall, the State Planning System is an effective analytical package that offers significant capabilities to state-level (and other) planners and analysts.

The New York State application of the model was quite complex, and although this created problems related to identifying appropriate relationships, compiling input data, and "tuning" the model, the software package was adaptable to the problem.

The State Education Department, though not one hundred percent satisfied with the State Financial Planning Model, is sufficiently interested to continue developing and refining it. This particular SPS design is not expected to become an operational tool in the near future; but as various aspects of the design are examined, refined, and improved it will be used in analyzing selected policy recommendations and validating selected "back-of-the-envelope" calculations.

Appendix II-A
Major Components of the Design

INCOME LEVELS

In some components of the model undergraduate student variables are categorized into three income groups. These income groups enable the model to reflect sensitivities of different policies to student income levels. The income levels, which refer to gross taxable balances, are:

Income Category	Gross Taxable Balance
High:	$15,000 +
Middle:	$7,500-$14,999
Low:	$0-$7,499

TUITION LEVELS

Tuition in this model is a control variable (i.e., when the model is run, tuition is free to seek a level that will provide "optimal" results). It is computed so that it includes all standard fees and excludes any tuition waivers and unfunded student aid. This exclusion probably introduces some bias in the computation of net cost to the student, but is more realistic in terms of institutional revenues.

Tuition is assumed to be the same for all students in a particular institutional sector regardless of their incomes. This means that any income-related tuition differentials that might be desirable are dealt with in the model by the "additional student aid" control variable.

COST TO STUDENTS

This portion of the model deals only with costs directly related to institutions (e.g., tuition and fees). Since it is the *percentage change* in net cost that enters into the important calculations in the model, it has been possible to provide estimates for some elements of the net cost that in other situations would have to be more accurate. Thus, the cost of room and board, net cost of Federal student aid, and travel costs have been estimated in the model to be equal to $1500 per FTUG.

Lack of data and technical difficulties related to adding more categories of students will hamper attempts to make this portion of the model more realistic.

STUDENT AID

Because of student aid programs in the State the net tuition price paid by students (i.e., the tuition charge less the Tuition Assistance Program (TAP) award and other awards) is dependent on family income. Student aid in the model includes only TAP, which is computed according to the actual formula. Programs for disadvantaged students or loan programs or Federal programs are not included, but could be included in future versions of the model.

TAP awards to full-time undergraduates are computed by reducing the maximum award ($1,500 or tuition, whichever is smaller) by an amount dependent upon income level. The income level determines the amount by which TAP is reduced from the maximum award. The result is then imputed over *all* FTE's (for both TAP and non-TAP recipients) within the given sector and income level using a TAP utilization rate which is essentially the percentage of students receiving TAP. Appendix B provides a more detailed presentation of the utilization rate. Graduate TAP is currently fixed at $156 in the model, which is the average actual award.

ENROLLMENT LEVELS

Enrollments are an important part of the model. They are included in the objective function, and a number of features have been incorporated into the model to permit adjustments in enrollments in response to other changes in the system. The base enrollment data are actual, historical figures collected and maintained by the State Education Department for the years 1969-75. Enrollment projections for future years are those developed by the State Education Department for the Regents 1976

Statewide Plan. For economy of operation, graduate enrollments have been fixed to the target levels in the current versions of the model; thus the model is useful for only examining the impacts of factors affecting undergraduate enrollments.

One of the most important features of the model is the shifting of enrollments from one sector to another that occurs in response to changes in the net prices charged to the students. These shifts are accomplished through the use of price elasticities which are estimates of the impact on enrollment levels of changes in net cost to students. The elasticities are based on a survey of 1974 TAP recipients in New York State. Elasticities for the City University are estimates based on an older national longitudinal study (Miller and Radner, 1975). These elasticities are used in conjunction with the estimates of the percentage change in net price (computed elsewhere) to compute adjustments in the numbers of new freshmen for each of the institutional sectors and years.

Once freshmen are admitted into the system they flow through the system according to transition rates and net price percentage change sensitivities. The transition rates are based on actual historical student progressions (see Appendix B). Price sensitivity of upperclassmen is assumed to be one quarter of the freshman sensitivity; this was felt to be more realistic than assuming no sensitivity at all.

INSTITUTIONAL EXPENDITURES

Estimates of institutional expenditures are based on a simple formula which incorporates fixed and variable cost components (Expenditures = A + B x enrollment). Separate equations have been developed for each institutional sector, and different coefficients have been provided for each type of student.

The coefficients are based on actual expenditure data reported by the institutions. The variable cost coefficients are based on Educational and General expenditures, reduced by items related to capital expenditures and other fixed cost items. An inflation factor has been applied to both the fixed and variable cost coefficients. The calculations and resulting coefficients are provided in Appendix B.

The fixed component of revenue is derived empirically by subtracting these variable revenues from the total revenues for the most recent year for which data exist (1974-75).

STATE OUTLAY

Total state outlay, which is also part of the objective function, is computed by summing all of the expenditure/revenue items that are attributable to the State including the five sector appropriations, TAP, and Regents Scholarships. It includes only those items that are part of the model, and does not include other major State programs (e.g., health, transportation).

INSTITUTION REVENUES

Institutional revenues in the model also have both fixed and variable components that fall into one of several major revenue categories:

- Tuition and fee income
- Gifts and endowment income
- Grants
- Sponsored programs
- Governmental appropriations
- Additional institutional aid
- Additional student aid

The major revenues included in the variable component are tuition and fee income, student aid income, and certain forms of governmental appropriations such as "Bundy Aid" which are mathematically computable as a function of student enrollment. Bundy aid is estimated on the basis of baccalaureate degrees conferred per undergraduate FTE, as well as graduate degrees conferred per graduate FTE. The per-student incremental revenues are applied to the price-adjusted enrollment projections in order to estimate the total variable revenues by institutional sector.

Appendix II-B
Detailed Specification of the Model

This appendix presents the detailed specification of the model for readers that are more technically inclined. It includes lists of the variables and their definitions, the equations used in the models, and the details of the objective function. Four conventions have been used in the detailed specifications:

1. Variables with names beginning with "X" are control variables (i.e., variables that are under the control of policy makers) which enter into the objective function in the model. The other variables are state variables which depend on the values of the control variables.

2. The subscript "J" defines institutional sectors

   J = 1 for SUNY 4-year plus Agricultural and Technical institutions
   2 for SUNY 2-year institutions
   3 for CUNY 4-year institutions
   4 for CUNY 2-year institutions
   5 for independent institutions

3. The subscript "I" defines the income groups for students

   I = 1 for high income students
   2 for moderate income students
   3 for low income students

4. The subscript "t" defines the year in which a particular relationship holds true.

VARIABLE LIST

Control (Decision) Variables

$XTUIT(J)_t$ = Average tuition cost in sector J, for full-time undergraduate students, in year t.

$XSUP(I,J)_t$ = Supply control; 1 - the fraction of first-time, full-time freshmen in income group I (I = 1,3) "turned away" by institutional sector J in year t; $0 \leq XSUP \leq 1$.

$XPTUG(J)_t$ = Part-time undergraduate enrollment in sector J, in year t (thousands of students).

$XFTG(J)_t$ = Full-time graduate enrollment in sector J, in year t (thousands of students).

$XPTG(J)_t$ = Part-time graduate enrollment in sector J, in year t (thousands of students).

$XADIA5_t$ = Additional state institutional aid (above Bundy formula) to institutional sector 5, in year t ($ millions).

$XADAID(I,J)_t$ = Additional student aid per full-time undergraduate (above TAP formulae) to students in income group I in sector J, in year t.

State Variables

$STAP(I,J)_t$ = Average TAP award to a full-time undergraduate student in income group I in sector J, in year t.

$SFTF(I,J)_t$ = Number of first-time full-time freshmen of income group I enrolled in sector J, in year t (thousands of students).

$SFTUG(I,J)_t$ = Number of full-time undergraduates of income group I, enrolled in sector J, in year t (thousands of students).

$SEXP(J)_t$ = Total expenditure of institutions in sector J, in year t ($ millions).

$SREV_t$ = Revenues of institutions in sector 5 (i.e., independent institutions) in year t.

$STAPG(J)_t$ = Average TAP award to a full-time graduate student in sector J, in year t.

Parameters and Constants

INC(I) = Average income of students in income group I.

TAPRED(I) = Percentage income reduction (TAP tables) for students in income group I.

UTRATE(I,J) = TAP utilization rate; percentage of students in income group I and sector J who receive TAP payments.

$PCNET(I,J)_t$ = Percentage change in net tuition price from year t-1 to t, for a full-time undergraduate student in sector J and income group I.

ATTRATE(J) = Number of full-time undergraduate students in sector J, "lost" from one year to the next due to transfer and graduation. ATTRATE(J) is determined empirically as follows:

ATTRATE(J) = 1-Retention Rate (J)

$$1-\frac{ftug_t-ftf_t}{ftug_{t-1}}=\frac{ftug_{t-1}-(ftug_t-ftf_t)}{ftug_{t-1}}$$

$BUNDYU_t$ = Total Bundy Aid for Associate and Baccalaureate degrees, in year t.

$BUNDYG_t$ = Total Bundy Aid for Master's and Doctoral degrees in year t.

FIXREV = Non-variable revenues for the independent sector (i.e., total revenues less tuition and Bundy).

IXK = 1000.

ELAST(I,J,K) = Percent of students in income group I enrolled in sector K, who transfer to sector J as a result of a 1% change in *net* tuition price in sector K.

GRTUIT(J) = Average graduate tuition charge in sector J.

$B(I,J)_t$ = Projected number of first-time freshmen in income group I in sector J (t = 1976/77,...,1980/81).

DETAILED EQUATIONS

State Equations

Note: The five sets of equations that follow are an important part of the model. They define many of the relationships that exist among the variables defined above. Where subscripts appear, they follow the same conventions shown on the appendix heading page except where noted.

1. Computation of TAP awards.
   Undergraduates:
   $STAP(I,J)_t$ = [min ($1500; $XTUIT(J)_t$) - INC(I,J) * TAPRED(1)] * UTRATE(I,J)
   Graduates:
   $STAPG(J)_t$ = 156 (applied to all full-time graduate students)

2. Computation of percentage change in price to students:
   $$PCNET(I,J)_t = [XTUIT(J)_t - STAP(I,J)_t - XADAID(I,J)_t -$$
   $$[XTUIT(J)_{t-1} - STAP(I,J)_{t-1} - XADAID(I,J)_{t-1}] +$$
   $$[XTUIT(J)_{t-1} - STAP(I,J)_{t-1} - XADAID(I,J)_{t-1}]$$

3. Enrollment Projections as modified by tuition price changes:
   Price Adjustment Factor:
   $$D(I,J)_t = \sum_K ELAST(I,J,K) * PCNET(I.K)_t$$
   (for K = 1,...5; J = 1,...5; I = 1,...3)

   First-Time Freshmen:
   $$SFTF(I,J)_t = [(B(I,J)_{t-1} - B(I,J)_{t-2}$$
   $$+ SFTF(I,J)_{t-1}) * (1. + D(I,J))] * XSUP(I,J)_t$$

   Full-Time Undergraduates:
   $$SFTUG(I,J)_t = SFTF(I,J)_t + SFTUG(I,J)_{t-1}$$
   $$- SFTUG(I,J)_{t-1} * ATTRATE(J)$$

4. Institutional Expenditures:

$$SEXP(J)_t = a_0 + a_1 * \sum_I SFTUG(I,J)_t + a_2 * XPTUG(J)_t + a_3 * XFTG(J)_t + a_4 * XPTG(J)_t$$

5. Institutional Revenues, Independent Sector Only:

Total Bundy Aid:

$$BUNDYU_t = b_1 \sum_I SFTUG(I,5)_t + b_2\, XPTUG(5)_t$$

$$BUNDYG_t = c_1 * XFTG(5) + c_2 * XPTG(5)_t$$

where b_1, b_2, c_1, c_2 are derived empirically.

Revenue Calculation:

$$SREV_t = \sum_I STAP(I,J)_t * SFTUG(I,J)_t + XTUIT(J)_t * [\sum_I SFTUG(I,J)_t + (1/3) * XPTUG(J)_t] + GRTUIT(J) * [XFTG(J)_t + .4 * XPTG(J)_t] + BUNDYU_t + BUNDYG_t + FIXREV + XADIA5_t + \sum_I XADAID(I,J)_t * SFTUG(I,J)_t;$$

for J = 5

Objective Function

General Form: min $Z = \sum [f_1(X) - G_1]^2$, where G's are goals to be attained

1. Full-Time Undergraduate Enrollment

Total FTUG: $[\sum_J \sum_I SFTUG(I,J)_t - G_1]^2$

a. SUNY-FTUG: $[\sum_I SFTUG(I,1)_t - G_{1a}]^2$

b. SUNY-2-FTUG: $[\sum_I SFTUG(I,2)_t - G_{2a}]^2$

c. CUNY-4-FTUG: $[\sum_I SFTUG(I,3)_t - G_{3a}]^2$

d. CUNY-2-FTUG: $[\sum_I SFTUG(I,4)_t - G_{4a}]^2$

e. INDEPENDENT-FTUG: $[\sum_I SFTUG(I,5)_t - G_{5a}]^2$

Where G_{1a} through G_{5a} are FTUG targets by sector.

2. Part-Time Undergraduate Enrollment

$[\sum_J XPTUG(J)_t - G_2]^2$

3. Full-Time Graduate Enrollment

$[\sum_J XFTG(J)_t - G_3]^2$

4. Part-Time Graduate Enrollment

$$[\sum_J XPTG(J)_t - G_4]^2$$

5. Balanced Budget for Independent Sector

$$[(SEXP(J)_t - SREV_t) - G_5]^2$$

6. State Outlays for SUNY, CUNY, and TAP

SUNY: State Share I = Expenditures less ("income offset" + amount by which calculated tuition revenue differs from base year tuition revenue)

SUNY-2-Year: State Share II = .40 * (Expenditures)

$$= .40 [SEXP\ (2)_t - \sum_I XTUIT\ (2)_t * SFTUG\ (I,2)_t$$

$$- XTUIT\ (J)_t * XPTUG\ (J)_t * .5]$$

CUNY-4-Year: State Share III = .50 * [SEXP $(3)_t$ - $\sum_I$ XTUIT $(3)_t$ * SFTUG $(I,3)_t$

- XTUIT $(J)_t$ * XPTUG $(J)_t$ * .5]
- GRTUIT $(J)_t$ * (XFTG $(J)_t$ + .4 * XPTG $(J)_t$)]

CUNY-2-Year: State Share IV = .40 * (Expenditures)

$$= .40 * [SEXP\ (4)_t - \sum_I XTUIT\ (4)_t * SFTUG\ (I,4)_t$$

$$- XTUIT\ (4)_t * PTUG\ (4)_t * .5]$$

Total State Share = State Share I + State Share II + State Share III + State Share IV.

TOTAL TAP:

$$TAPTOT_t = \sum_J \sum_I STAP\ (I,J)_t * SFTUG\ (I,J)_t$$

$$+ \sum_J STAPG\ (J)_t * XFTG\ (J)_t + \sum_J \sum_I XADAID\ (I,J)_t * SFTUG\ (I,J)_t$$

TOTAL STATE EXPENDITURES:

$$[(Total\ State\ Share_t) + TAPTOT_t + (BUNDYU_t + BUNDYG_t) + XADIA5_t - G_6]^2$$

Appendix II-C
Parameter Estimation for the Model

ENROLLMENTS

The enrollments for 1974-75 and 1975-76 used in this study are actual figures collected by the State Education Department as maintained in the Higher Education Data System in the Office of Postsecondary Research, Information Systems and Institutional Aid. Projected enrollments are from the Regents' Statewide Plan for Postsecondary Education for 1976. Both actual and projected enrollments in all student categories have the following exclusions:

public institutions - Health and Science Centers
- Specialized Colleges
- Statutory Colleges

independent institutions - Health and Science Centers
- Seminaries
- Two-Year Degree-Program Institutions

The State University-State Operated Sector (4-year institutions) includes enrollments from the Agricultural and Technical schools because of the similar funding patterns.

Because of these differences in institutional categories the projected enrollments are not in the same groupings as used in the planning model. Empirical conversion rates were developed to reflect all the differences in the classification schemes.

Table B.1 summarizes the effect of the exclusions for the State University-State Operated and the Independent sectors.

For part-time undergraduates an empirical ratio based on a weighted average of historical percentages was developed to extract the Agricultural and Technicals from the State University two-year cate-

Table B.1

Percent of Total Enrollment Remaining After Exclusions (1969-70 to 1975-76)

	SUNY-State Operated				Independent Colleges			
	Undergraduates		Graduates		Undergraduates		Graduates	
	FT	PT	FT	PT	FT	PT	FT	PT
1969-70	91.2	98.8	63.3	98.7	98.6	99.5	90.7	99.4
1970-71	91.2	99.2	66.5	98.6	98.9	99.5	91.9	99.4
1971-72	91.0	98.5	67.6	98.4	98.9	99.7	91.4	99.5
1972-73	90.6	98.4	65.2	97.9	98.9	99.2	91.6	99.2
1973-74	90.6	97.0	62.7	96.6	98.6	99.3	91.1	98.9
1975-76	90.9	94.6	64.7	96.1	98.8	99.6	90.1	98.9
Average*	90.9	97.0	64.8	97.1	98.8	99.4	90.9	98.9

*Weighted average – heavier emphasis placed on more recent enrollments – i.e. (1, 2, 3, 4, 5, 6)

gory and include them with the State University-State Operated Schools. Table B.2 summarizes the part-time undergraduate ratio.

Also required in the enrollment database are data on full-time freshmen. Since these enrollments are not explicitly projected in the Statewide Plan, they have been derived as an empirical percentage of full-time undergraduates. Table B.3 summarizes the empirical basis for this ratio. Projected full-time freshmen are derived by applying the empirical ratio to the appropriate full-time undergraduate projections.

Given this empirical basis for developing the enrollment database by sector, the full-time undergraduates and full-time freshmen are then broken down into three income levels. This is accomplished by using the same student income level percentages as discussed in the TAP section later in this Appendix.

Tables B.4 through B.8 display the detailed enrollments used in the planning model that reflect all exclusions and modifications. Each table represents one student type (e.g., full-time undergraduate) and shows the breakdown by sectors.

Table B.2

Agricultural and Technical as a Percentage of SUNY–2 Year Enrollment (1969-70 to 1974-75)

	1969-70	1970-71	1971-72	1972-73	1973-74	1974-75	1975-76
Ag. & Techs.	5,568	6,613	7,565	8,045	7,146	7,282	8,332
Total SUNY–2 Year	53,028	56,199	60,383	63,266	65,895	70,520	81,886
Ag. & Tech. Percentage	10.5%	11.8%	12.5%	12.7%	10.8%	10.3%	10.2%

Note: The weighted average of Agricultural and Technical percentages equals 11.1 percent, where the weighting scheme = (1, 2, 3, 4, 5, 6, 7).

Table B. 3

First-Time Freshmen* as a Percentage of Full-Time Undergraduates* (1973-74 to 1975-76)

	1973-74			1974-75			1975-76			
	FTE	FTUG	FTE/FTUG	FTF	FTUG	FTF/FTUG	FTF	FTUG	FTF/FTUG	Weighted Average by Years**
SUNY–State Operated	31,422	109,564	.287	31,810	115,536	.275	33,143	122,528	.270	.276
SUNY–Community Colleges	34,355	69,016	.498	34,355	72,557	.473	37,041	83,061	.446	.466
CUNY–Senior Colleges	16,755	84,602	.198	17,758	87,220	.204	16,993	87,550	.194	.198
CUNY–CC	14,422	41,291	.349	16,193	43,938	.369	13,680	40,170	.341	.350
Independents	42,525	168,911	.251	46,342	176,255	.262	48,792	189,438	.257	.257

*All exclusions taken into account.
**Weighting factor = (1, 1, 2)

Table B.4

Full-Time First-Time Freshman Enrollments

	Actual			Projected				
	1973-74	1974-75	1975-76	1976-77	1977-78	1978-79	1979-80	1980-81
SUNY–State Operated	31,419	31,807	33,140	31,131	31,483	31,809	32,160	33,201
SUNY–Community Colleges	34,358	34,355	37,041	40,076	38,445	37,839	37,234	37,644
SUNY–Senior Colleges	16,744	17,748	16,983	14,459	11,674	10,368	10,943	11,695
CUNY–Community Colleges	14,413	16,283	13,671	15,740	16,336	18,889	17,665	16,616
Independents	42,525	46,342	48,792	49,082	49,717	47,069	44,613	45,514
Total Full-Time First-Time Freshman Enrollments	139,459	146,535	149,627	150,488	147,655	145,974	142,615	144,670

Table B.5

Full-Time Undergraduate Enrollments

	Actual			Projected				
	1973-74	1974-75	1975-76	1976-77	1977-78	1978-79	1979-80	1980-81
SUNY–State Operated	109,564	115,600	122,528	114,627	115,829	116,995	118,226	121,953
SUNY–Community Colleges	69,016	72,557	83,061	86,000	82,500	81,200	79,900	78,850
CUNY–Senior Colleges	84,602	87,220	87,550	73,050	59,000	52,400	55,300	59,100
CUNY–Community Colleges	41,291	43,938	42,665	45,000	46,700	54,000	50,500	47,500
Independents	168,911	176,255	190,068	191,064	193,928	192,396	183,206	177,178
Total Full-Time Undergraduate Enrollments	473,384	495,570	525,872	509,741	497,957	446,991	487,132	484,581

Table B.6

Part-Time Undergraduate Enrollments

	Actual			Projected				
	1973-74	1974-75	1975-76	1976-77	1977-78	1978-79	1979-80	1980-81
SUNY–State Operated	21,093	23,529	25,831	27,471	27,865	28,569	28,625	28,774
SUNY–Community Colleges	58,749	63,238	73,554	73,965	75,565	76,543	76,987	78,188
CUNY–Senior Colleges	46,502	49,382	50,964	48,650	42,800	37,300	39,400	38,750
CUNY–Community Colleges	37,032	40,428	42,712	37,350	35,300	39,000	41,000	43,000
Independents	53,096	55,325	60,248	63,873	66,706	67,702	68,498	69,293
Total Part-Time Undergraduate Enrollments	216,472	231,902	253,309	251,309	248,236	249,114	254,510	258,005

Table B.7

Full-Time Graduate Enrollments

	Actual			Projected				
	1973-74	1974-75	1975-76	1976-77	1977-78	1978-79	1979-80	1980-81
SUNY—State Operated	9,118	9,414	10,135	10,498	10,627	10,951	11,178	11,405
SUNY—Community Colleges	0	0	0	0	0	0	0	0
CUNY—Senior Colleges	4,842	5,613	4,515	3,600	3,400	3,400	3,500	3,600
CUNY—Community Colleges	0	0	0	0	0	0	0	0
Independents	37,623	38,007	39,138	40,451	40,723	42,268	43,087	43,905
Total Full-Time Graduate Enrollments	51,583	53,034	53,788	54,549	54,750	56,619	57,765	58,910

Table B.8

Part-Time Graduate Enrollments

	Actual			Projected				
	1973-74	1974-75	1975-76	1976-77	1977-78	1978-79	1979-80	1980-81
SUNY—State Operated	23,494	24,796	24,748	25,537	26,023	26,411	26,945	27,479
SUNY—Community Colleges	0	0	0	0	0	0	0	0
CUNY—Senior Colleges	27,244	26,375	22,422	16,600	16,000	16,000	16,500	17,000
CUNY—Community Colleges	0	0	0	0	0	0	0	0
Independents	67,640	72,713	75,688	81,889	84,164	85,944	87,378	88,812
Total Part-Time Graduate Enrollments	118,378	123,884	122,858	124,026	126,187	128,355	130,823	133,291

INSTITUTIONAL EXPENDITURES

Expenditure equations for each of the five sectors were derived empirically to provide a basis for estimating the total expenditures for each institutional sector. Each cost equation contains a fixed component and at most four variable components. The general form of the equations for a given institutional sector is as follows:

Total
Expenditure = A + B * # full-time undergraduates
+ C * # part-time undergraduates
+ D * # full-time graduates
+ E * # part-time graduates;

where A is the fixed cost component not dependent upon enrollment levels, and

B,C,D, and E are the variable costs associated with each student type.

The same procedure was used to determine the expenditure coefficients for each institutional sector. Using actual expenditure data for 1970-71 to 1973-74, an adjusted E & G figure was derived based on an empirical percentage of total E & G. The difference between total expenditure and adjusted E & G was defined to be the fixed cost component.

The variable cost coefficients for a given sector are based on 1974-75 expenditures and enrollment data. Total FTE's were computed for each institutional sector (as converted from the four student types), where the graduate FTE's were inflated by a

factor of 1.78 to reflect the additional workload and expense they involve.[1] Through this factor a higher cost is attributed to graduate FTE's in the model. The total weighted FTE's are then divided into the adjusted E & G figure to yield the variable cost for FTE, which corresponds to full-time undergraduates. The FTE variable cost for the other types of students is then computed by multiplying this FTUG cost by the appropriate factor (e.g., 1.78 for graduate students). The specific calculations for the four sectors, based on 1974-75 data, are presented below:

Expenditure Coefficients for SUNY-State Operated[2]

Total Expenditures (including fringes)	$717,310,000
less Fixed Cost Component[3]	-283,101,000
Adjusted E & G Cost	$434,209,000

number FTUG = 115,536
number PTUG = 23,529
number FTG = 9,414
number PTG = 24,796

Let X = cost/FTE

$X[115{,}536 + .5\,(23{,}529)] + 1.78\,[9{,}414 + .4\,(24{,}796)]\,X = (161{,}713)\,X = \$434{,}209{,}000$

cost/FTUG = X = $2,685
cost/PTUG = (.5)X = $1,343
cost/FTG = (1.78)X = $4,779
cost/PTG = (1.78)(.4)X = $1,912

Thus: SUNY-State Operated Total Expenditure =

$\$283{,}097{,}000^{4} + \$2{,}685_{X}(\text{FTUG}) + \$1{,}343_{X}(\text{PTUG}) + \$4{,}779_{X}(\text{FTG}) + \$1{,}912_{X}(\text{PTG})$

[1]This 1.78 cost differential factor corresponds very closely to results in two independent studies:
1. SUNY - A Study of E & G Costs. (1974-75).
2. CICU - SUNY State-Operated Institutions - Calculation of the Cost to New York State. (1974-75).

[2]Coefficients for this sector correspond closely with those in the SUNY Study of E & G Costs (1974-75).

[3]Fixed component includes all costs (including fringe benefits for those schools not in the study).

[4]Difference from fixed cost above is due to round-off error.

Expenditure Coefficients for SUNY Community Colleges

Total Expenditures (including fringes)	$214,463,000
less Adjusted E & G Cost	-203,319,000
Fixed Cost Component	$ 11,144,000

Adjusted E & G Cost = (Total E & G Cost) x (.98289)
= (206,858,000) x (.98289) = $203,319,000

number FTUG = 72,557

number PTUG = 63,238

Let X = cost/FTE

X[72,557 + .5(63,238)] = $203,319,000

(104,176) X = 203,319,000

cost/FTUG = X = $1,952

cost/PTUG = (.5) X = $ 976

Thus SUNY-Community College Total Expenditure = $11,111,000* + $1,952 x (FTUG) + $976 x (PTUG)

*Difference from fixed cost above is due to round-off error.

Expenditure Coefficients for CUNY-Senior Colleges

Total Expenditures (including fringes)	$389,953,000
less Adjusted E & G Cost	-343,994,000
Fixed cost component	$ 45,959,000

Adjusted E & G Cost = (Total E & G Cost) x (.96299)
= (357,214,000) x (.96299) = $343,994,000

number FTUG = 87,220
number PTUG = 49,382
number FTG = 5,613
number PTG = 26,375

Let X = cost/FTE

X [87,220 + .5(49,382)] + 1.78[5,613 + .4(26,375)] X = (140,681) X = $343,994,000

cost/FTUG = X = $2,445
cost/PTUG = (.5) X = $1,223
cost/FTG = (1.78) X = $4,352
cost/PTG = (178)(.4) X = $1,741

Thus: CUNY-Senior College Total Expenditure =

$45,959,000* + $2,445 x (FTUG)
+ $1,223 x (PTUG)
+ $4,352 x (FTG)
+ $1,741 x (PTG)

*Difference from fixed cost above is due to round-off error.

Expenditure Coefficients for CUNY Community Colleges

Total Expenditures (including fringes)	$165,759,000
less Adjusted E & G Cost	-149,457,000
Fixed Cost Component	$ 16,302,000

Adjusted E & G Cost = (Total E & G Cost) x (.96994) = (154,089,000) x (.96994) = 149,457,000

number FTUG = 43,938

number PTUG = 40,428

Let X = cost/FTE

X[43938 + .5 (40428)] = 149,457,000

(64,125) X = 149,457,000

cost/FTUG = X = $2,330

cost/PTUG = (.5) X $1,165

Thus: CUNY-Community College Total Expenditure = $16,285,000* + $2,330 x (FTUG) + $1,165 x (PTUG)

Expenditure Coefficients for Independent Colleges

Total Expenditures	$1,788,608,000
less Adjusted E & G Cost	-1,164,355,000
Fixed Cost Component	$ 624,253,000

Adjusted E & G Cost = (Total E & G Cost) x (.80043) = (1,454,662,000) x (.80043) = $1,164,355,000

number FTUG = 173,771

number PTUG = 53,340

number FTG = 32,988

number PTG = 67,482

Let X = cost/FTE

X[173,771 + .333 (53,340)] + 1.78 [32,988 + .4(67,482)] X = (298,317) X = 1,164,335,000

cost/FTUG = X = $3,903

cost/PTUG = (.333) X = $1,301

cost/FTG = (1.78) X = $6,947

cost/PTG = (1.78)(.4) X = $2,779

Thus: Independent Colleges Total Expenditure = 624,284,000* + $3,903 x (PTUG) + $1,301 x (PTUG) + $6,947 x (FTG) + $2,779 (PTG)

*Difference from fixed cost above is due to round-off error.

TUITION RATES BY SECTOR

The model uses tuition rates by sector and does not distinguish between lower and upper division undergraduate tuition rates as is actually done in the public sector. State University-State Operated tuition in the model is a weighted average of the upper and lower division tuition rates, where the weighting is based on enrollments. For 1974-75 the weighted tuition rate for the State University-State Operated sector is $710. The newly imposed SUNY tuitions yield $810 and $670 rates for State University Operated and Community Colleges, respectively, using the same computational procedures.

Tuition at State University Community Colleges was determined by dividing gross tuition and fee income (1974-75) by the number of FTE students. This resulted in a tuition rate of $570 per FTE:

Gross tuition revenue 1974-75	$59,465,000
number of FTE's	104,176
Tuition/FTE	$570

The City University Senior and Community colleges average tuition and fee rates for the years preceding 1976-77 were derived from enrollment and tuition and fee revenue data. The average rate for both the Senior colleges and the Community Colleges was $160. City University Senior college tuition rates for 1976-77 and beyond are estimated to be $835 (a weighted average of upper and lower division tuition rates, $925 and $775, respectively). For the Community Colleges tuition for beyond 1976 is $775, based on the same procedures.

Tuition for the independent sector is estimated by dividing total FTE students into gross tuition and fee revenues.

For 1973:

Gross tuition and fee revenue	$652,338,000
Number of FTE's	242,354
Estimated 1973 Tuition: $2,692	$ 2,692

For 1974:

Gross tuition and fee revenue	$752,033,000
Number of FTE's	261,889
Estimated 1974 Tuition: $2,871	$ 2,871

Tuition for 1975-76 was imputed from CICU estimates for full-time undergraduate tuition. CICU estimates for FTUG tuition from 1973-74 are:

1973-74	$2,538
1974-75	$2,634
1975-76	$2,790

The planning model tuitions are different from those of CICU for 1973-74 and 1974-75 because they are imputed from both graduate and undergraduate tuition and fee revenues. By increasing the planning model tuition estimate for the independent sector in the same proportion that the CICU estimates increase, we get $3,041 as the 1975-76 tuition rate for use in the model.

BUNDY AID CALCULATIONS

An empirical relationship between student types and degree types conferred was developed (based on 1973-74 data) in order to estimate Bundy aid as a function of students. Bundy aid is currently disbursed to eligible institutions based upon the number and types of degrees conferred. The 1975-76 disbursement rates per type of degree are:

Bachelors	$ 800
Masters	$ 600
Doctorals	$3,000

The following pair of equations summarizes the relationships between degree types and students for undergraduates and graduates:

Bachelor degrees conferred =
A* Full-time Undergrads
+ B* Part-time Undergrads

Graduate degrees conferred =
C* Full-time Graduates
+ D* Part-time Graduates

where A = .2254; B = .0330; C = .2994; D = .2103, based on empirical coefficients estimated from actual historical data using regression analysis. All four coefficients are statistically significant at the 95% confidence level.

Bundy aid for the future years is then computed as a function of the degrees conferred in the previous year as estimated using the "completion coefficients."

The regression analysis included all institutions eligible for Bundy aid. Since the analysis in the planning model excludes medical schools, appropri-

ate adjustments were made. In addition, since the Bundy institutions are not segregated in the planning model from the rest of the private sector, a utilization rate of about 90% had to be applied to the empirical coefficients, because enrollments in "Bundy institutions" account for about 90% of the students in the independent sector. Thus, the Bundy aid amount calculated has been adjusted to reflect only the "Bundy institutions."

PARAMETER ESTIMATION FOR TAP FORMULAS

The planning model categorizes students into three income levels as follows:

Gross Income		*Average Net*
0-$7,499	Low Income	$ 1,347
$7,500-$14,999	Middle Income	$ 5,485
$15,000+	High Income	$12,214

The percentage of students within each income level is different for the five sectors as shown in Table B.9.

Given these average income levels, the TAP formulas can be completed. For each income level, the reduction from the maximum award (lesser of tuition or $1,500) and the upper limit on the award can be computed based on the actual TAP formula. The actual figures used in the model are:

	Low Income	Middle Income	High Income
TAP Reduction	$ 0	$ 215	$750
TAP Limit	$1,500	$1,285	$750

UTILIZATION RATE FOR TAP COMPUTATIONS

Since not all students are TAP recipients, a utilization rate is used to impute TAP awards over all full-time undergraduates. The utilization rates by sector, based on historical State Education Department data, are:

SUNY-State Operated	72.72%
SUNY-Community Colleges	60.77%
CUNY-Senior Colleges	72.72%
CUNY-Community Colleges	60.77%
Independent Colleges	46.03%

Because no historical TAP information for the City University exists, the State University utilization rates have been used.

FIXED REVENUE COMPONENTS

Both the independent sector and the State University-State Operated sector have significant fixed revenues that must be accounted for. The resulting figures were used for all subsequent years in the models, with appropriate adjustments for inflation.

Independent Sector

To determine the fixed revenue component for the independent sector, tuition and fee income (1974-75)was subtracted from total current fund revenues. The result was approximately $928 million. This figure takes into account the exclusion of schools not in the analysis (i.e., medical schools).

Total Current Fund Revenues (1974-75)	$1,680,341,000
Less: Tuition and Fee Income (1974-75)	$ 752,033,000
Fixed Revenues Component	$ 928,308,000

SUNY-State Operated

Estimation of the fixed revenue component is more complicated for the State University because of funding procedures. The State appropriation for

Table B.9

Student Densities by Income Level by Sector

	Low Income	Middle Income	High Income	Total
SUNY–State Operated	23.89%	37.22%	38.89%	100%
SUNY–Community Colleges	26.57%	39.27%	34.16%	100%
CUNY–Senior Colleges	27.50%	37.45%	35.05%	100%
CUNY–Community Colleges	27.50%	37.45%	35.05%	100%
Independent Colleges	26.26%	34.94%	38.80%	100%

SUNY-State Operated institutions is total expenditures, less an "income offset" which represents the net income remaining after debt service has been subtracted from the gross tuition and fee revenues. The "income offset" fluctuates from year to year in response to budgeting and legislative demands.

For the purposes of the planning model a figure of $90 million has been used as the "income offset" for the run year (1974-75). This figure, which is a rough estimate based on discussions with State University staff, is one possible area in which the model could be improved. Changes in the "income offset" in subsequent years are related to changes in tuition revenues from the run year (1974-75 tuition revenue: $115.8 million). Thus, the $90 million "income offset" is adjusted by the amount by which the tuition revenue differs from the 1974-75 tuition revenue.

STUDENT TRANSITION RATES

In the present formulation it is assumed that once students are enrolled they progress through the institutions according to a predetermined pattern (i.e., increases in tuition do not affect transition rates). The term transition rate is used instead of attrition rate because the empirical rates used in the model are indicative of more than just attrition; it includes implicitly dropouts, continuing and returning students, and transfer students as well. The transition rate is determined empirically as follows:

Transition rate$_t$ = 1 - retention rate

$$= \frac{1\text{-}FTUG_{t+1}\text{-}FTE_{t+1}}{FTUG_t}$$

$$= \frac{FTUG_t\text{-}(FTUG_{t+1}\text{-}FTF)_{t+1};}{FTUG}$$

where FTUG = full-time undergraduate in year t,
FTF_t = full-time first time frosh in year t,
t = year

Table B.10 displays the empirical transition estimates for each sector used in the models. Both five-year average transitions and regression-based estimates are shown. The planning model currently uses the regression estimates because it is believed they are more indicative of recent trends.

Table B.10

Transition Rates of Enrolled Students, by Sector*

	SUNY 4-yr.	SUNY 2-yr.	CUNY 4-yr.	CUNY 2-yr.	Independents
1969-70	.17097	.43883	.11646	.32035	.24314
1970-71	.20628	.44854	.14987	.36575	.24068
1971-72	.24980	.49075	.20932	.27660	.26826
1972-73	.23543	.47229	.16945	.31977	.25870
1973-74	.22874	.44788	.17928	.33215	.20896
Average	.21824	.45966	.16308	.32292	.24395
Regression	.22182	.46115	.17042	.32073	.24451

*The figures in the table represent the proportion of the current year's undergraduate class that will *not* be carried forward to the following year.

**Regression model used has the following:

$$N_t = B^* (FTUG_t)$$

Where: N_t = net result in year t of $[FTUG_t - (FTUG_{t+1} - FTE_{t+1})]$
B = coefficient to be determined by the regression run.

PRICE AND INCOME ELASTICITY OF DEMAND FOR POSTSECONDARY EDUCATION BY SECTOR

To reflect the sensitivity of students to changes in the cost of college attendance, elasticities of demand are incorporated into the model. The elasticities in the model are estimates of the percentage change in enrollment in a given institutional sector given a one percent change in net price (ECON, 1976). Net price for a given student is defined to be tuition plus $1,500* less scholarship awards (e.g., TAP awards) and Federal aid.

The sample of students used in estimating the elasticities was drawn from 1974 TAP recipients and was therefore biased. It did not deal with any City University data, hence, CUNY price elasticities and "recapture rates" were based on State University figures. Thus, in the model the percentage of students migrating to other sectors as a result of a price change in a CUNY sector is the same as for the corresponding SUNY sector.

The price elasticities used in the model are displayed by income level in Table B.11. A comparison was made between the new elasticities and the price response coefficients used in other studies of student demand (National Commission on the Financing of Postsecondary Education, 1974). Assuming $100 increases in net price, percentage changes in net price were calculated by sector and income level and applied to the price elasticities in Table B. 11 to estimate the effect of a $100 increase in net price.

Compared to the elasticities used in the planning model price response coefficients used by the NCFPE are three to five times more sensitive to a $100 change in price. This is an indication that the 1974 TAP recipients were significantly less concerned about changes in net cost than were the students in the 1972 national study. This is not entirely surprising since the TAP recipients are already enrolled in college and have been provided aid.

Migration of students from one sector to another as estimated from the cross-elasticities also appears to be less. The middle and high income price elasticities have smaller migration rates to other sectors due to a price change.

The elasticities used in the model are probably its "weakest link." Additional effort to obtain and validate these important coefficients is warranted.

*$1,500 is a rough estimate of the food, housing, and other miscellaneous costs incurred by students not included in the tuition charges.

Table B.11

Price Elasticities by Income Level*

% Change in Enrollment in / One % Change in Net Price in	SUNY St. Oper	SUNY CC	CUNY Senior	CUNY CC	Independent
Low Income					
SUNY–State Operated	–.21	.03	.04	.02	.06
SUNY–CC	.01	–.11	.01	0.	.01
CUNY–Senior	.06	.03	–.21	.02	.06
CUNY–CC	.01	0.	.01	–.11	.01
Independents	.03	.02	.02	.01	–.12
Middle Income					
SUNY–State Operated	–.28	.02	.05	.02	.07
SUNY–CC	.01	–.17	.01	0.	.03
CUNY–Senior	.10	.02	–.28	.02	.07
CUNY–CC	.01	0.	.01	–.17	.03
Independents	.05	.03	.03	.03	–.13
High Income					
SUNY–State Operated	–.27	.02	.03	.01	.07
SUNY–CC	.02	–.19	.01	0.	.03
CUNY–Senior	.07	.02	–.27	.01	.07
CUNY–CC	.02	0.	.01	–.19	.03
Independents	.11	.05	.05	.02	–.12

*Percentage change in enrollment caused by a one percent change in net price.

EXCLUSION OF COSTS IN TOTAL STATE EXPENDITURES

Costs not included in total state expenditure 1974-75	Dollars in Millions
1. Aid to non-public other than Bundy Aid - Medical and Dental Schools - Expansion	$21.2
2. Programs for Disadvantaged Students	17.2
3. Misc. State Education Dept. Programs - SED - Higher Education Services - SED - Professional Education Services - Regents Exam. & School Services - Einstein and Schweitzer Chairs - Teacher Training Grants - Education of Native Americans	9.2
4. Other SUNY Appropriations	14.2
5. Apps. to other State Agencies	7.5
6. Misc. Aid to Students - SUNY Scholarships - Fellowships	10.2
TOTAL	$79.5

Glossary

This glossary contains a number of terms that are associated with the State Planning System. The index which follows provides references to the SPS documents for these terms as well as for other terms that are not listed here.

Constant Value (K). An SPS variable type used to store values that are fixed throughout a run of SOM.

Control Variable (C). An SPS variable type used to store values that may be modified by SOM if an optimization run is made.

Data and Report Module (DRM). The data manager and report writer for the SPS. DRM can create the data base and description file used by SOM and can produce tables or plots of the results of one or more runs of SOM. Other uses of DRM are to: (1) produce summaries of the data base and description files, (2) produce a listing of the design file values, (3) produce update files to modify data values before a run of SOM, (4) write subsets of data base or description files, (5) produce files used to modify existing data base or description files, and (6) sort small data base or description files.

Data Base File (DB). A file which contains all the data values used by a design. Each data value is identified by the time period, variable type and index, sector, and run number associated with that value.

Description File (DC). A file which contains all the labels (descriptions) used to identify the output of an SPS design. These labels are provided by the user to identify each variable used in a design.

Design. The overall set of relationships, data identifiers, and control parameters used in an SPS application.

Design File (DF). A file which provides the definition of an SPS design. The design file describes the number of variables, number of planning periods, basic design characteristics, and labels of a design.

Design Subroutines File (DS). A file which contains the actual relationships used in an SPS design. The design subroutines (consisting of three FORTRAN subroutines with a standard calling sequence, STATE, TERMS, and MSRS) are provided by the user. These routines are called by SOM when making a run.

Dynamic Variable (D). An SPS variable type used to store computed values that flow from one time period to the next.

Exogenous Value (E). An SPS variable type used to store values that are fixed throughout a run of SOM.

Index. A key used to identify a variable of a given type; each variable in an SPS design is identified by its SPS variable type and by an index value. For example, control variables one, two, three, four, etc.

INTABL. The standard instruction table file which must be provided for each run of SOM and DRM.

Key. An identifier used in the SPS to identify records and link file types together. The six SPS keys are: design, run, sector, type, index, and time.

Lagged Data References. The incorporation of historical data values in design equations.

Lower Bound (L). An SPS variable type used to store the lower bound for its associated control variable.

Measure Variable (M). An SPS variable type used to store values, calculated within a time period, that are used only for reporting purposes.

Merge Module (MRG). The file merger for the SPS. MRG can append the results of several runs of SOM together so that DRM can be used to produce reports comparing the runs. MRG can also modify existing data base or description files by merging them with special modification files produced by DRM.

Modify Data Base File (MDB). A small data base file created in DRM and used with MRG to modify an existing data base file.

Modify Description File (MDC). A small description file created in DRM and used with MRG to modify an existing description file.

MSRS Subroutine. The standard routine used to compute the measure values in the design subroutines file.

New Data Base File (NDB). The new data base file created by a run of SOM, DRM, or MRG.

New Description File (NDC). The new description file created by a run of DRM or MRG.

Optimization. The capability of SOM to adjust the control variables in a design to bring the term variables closer to their target values.

Print Switches. Values on the design file that are used to control the output produced by SOM.

Report File (RP). The output file of reports produced by SOM. It can be saved for later listing on a terminal or a line printer.

Run Number. The key value used to identify each data base produced by a run of SOM.

Run-Time Updates. Temporary modifications to certain design file values that are made during the course of a run of SOM.

Scale Factor (A). An SPS variable type used to store the scale factor for its associated control variable.

Sector. A grouping of data in an SPS design corresponding to one component of the design (e.g., a particular institution or a set of similar institutions). They are distinguished from each other by the sector key.

Sector Communication Table (SCT). The specification of the data values that are to be passed from one sector to another during a run of SOM. Unlike the DS, DB, DC, and DF files, the sector communication table file is not used with every SPS design.

Simulation. The capability of SOM to calculate the static, dynamic, term, and measure values for all the time periods in a design.

Simulation and Optimization Module (SOM). The computational module for the SPS. SOM is used for either simulation or optimization runs with the designs specified in the SPS data files. SOM produces certain standard reports on request and a new data base file containing the results of the current run.

STATE Subroutine. The standard routine used to compute the dynamic and static values in the design subroutines.

Static Variable. An SPS variable type used to store values computed within a time period.

Subdesign. The relationships and characteristics of an SPS design that apply to at least one sector. There may be several subdesigns in an SPS design and they are distinguished by the design key.

Subroutine. A unit of FORTRAN computer code that makes up part of a complete program. The user supplies the three design subroutines to SOM for each SPS design.

Target Value (T). An SPS variable type used to store the goal or desired value of its associated term variable.

TERMS Subroutine. The standard routine used to compute the term values in the design subroutines.

Term Variable (R). An SPS variable type used to store the calculated value of a design objective within a time period.

Time Period. The units of time in an SPS design. The values are determined by the user (that is, the time periods can be academic years, fiscal years, semesters, etc.) and are distinguished by the time key.

Update File (UP). The file used as an update to the data base during a run of SOM. It is created as an NDB file in DRM.

Upper Bound (U). An SPS variable type to store the upper bound for its associated control variable.

Variable Types. The set of twelve allowable variable types used in constructing a design for the SPS.

Weight Value (W). An SPS variable type used to indicate the relative importance of its associated term variable in a design.

Index

This index combines entries for all 12 State Planning System documents. Each entry is followed by a subentry for each document that contains a reference to that subject. The documents are abbreviated in the subentries as follows:

I	*Introduction to SPS*
M	*Modeling and SPS*
CS	*SPS Case Studies*
DP	*SPS Data Procedures*
DG	*SPS Design Guide*
GTM	*SPS General Training Manual*
ISTM	*SPS In-State Training Manual*
OG	*SPS Operation Guide*
SD	*SPS Software Documentation*
SIG	*SPS Software Installation Guide*
SOI	*SPS Summary Operating Instructions*
TC	*Theoretical Concepts Used in SPS*

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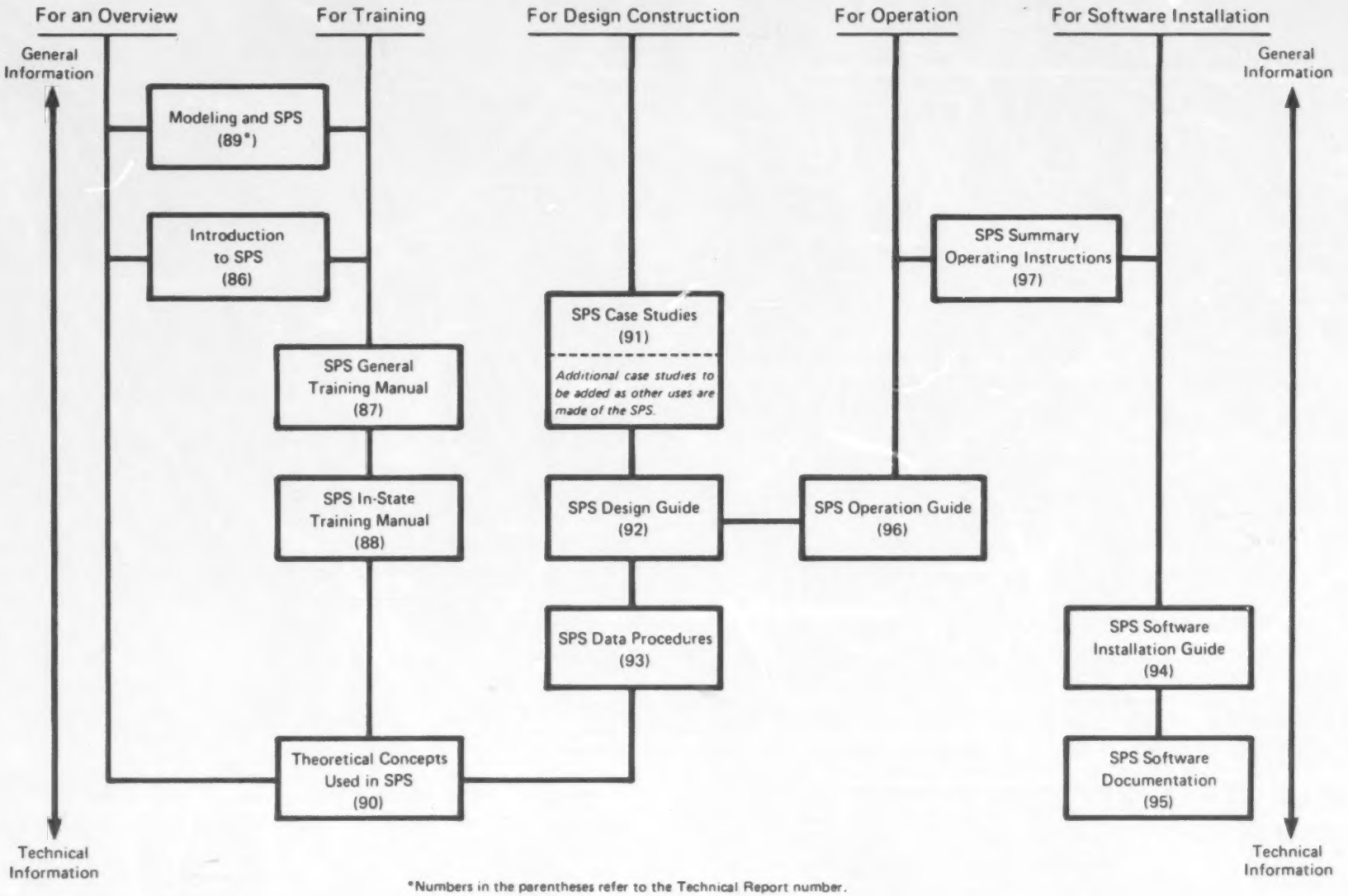
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